A SYNOPSIS AND ANALYSIS OF RESEARCH ON SURPLUS REQUIREMENTS FOR PROPERTY AND CASUALTY INSURANCE COMPANIES

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submitted by

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1

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INTRODUCTION

The continuing solvency of property and casualty insurance companies, as well as of other financial institutions, has become an issue of great importance and major concern during the past decade. While solvency has always been a major consideration for actuaries, the experience of multiple failures of financial institutions in the past several years has caused the profession to focus more attention on the problem. The emerging role of the valuation actuary, as well as the renewed interest of legislators in the solvency issue, have added a sense of urgency to the profession's need to better evaluate solvency.

This report has been commissioned by the Committee on Financial Analysis of the Casualty Actuarial Society to lay the groundwork for future research on surplus requirements for property and casualty insurers in a North American context. The largest part of this report is an annotated bibliography of relevant research papers. These are found in the bibliography. The bibliography provides a foundation for future research. For convenience, all papers cited have been grouped according to general subject area. The subject classification, which contains a list of the major approaches to the solvency problem itself, is described in the first section of this report. Papers are listed alphabetically by author and are also grouped according to subject classification. The most promising approaches for further study and development are evaluated and discussed in the second section.

1. CLASSIFICATION OF RESEARCH AREAS

The bibliography to this report contains a comprehensive listing of research reports published in English which relate to the solvency of property and casualty insurance companies. Each paper has been classified according to its primary approach or subject matter. A particular paper may touch on categories other than its primary classification. The classification system is described below. The categories listed span an area wider than the strict subject of solvency; many of the papers cited have implications for solvency but are not strictly papers on solvency.

I.   Classical Risk Theory

One approach to solvency evaluation has been through classical risk theory, particularly the branch known as ruin theory. This is a well-established area, described in a number of well-known text books as listed in the bibliography to this report. Also included in this category are papers which study solvency through various probabilistic models which do not involve detailed cash flow simulations.

II.   Projection Simulation Models

With the development of computers, renewed attention has been focused on the use of cash flow projection models to study, among other things, the continuing solvency of insurance companies and their sensitivity to various sources of risk. This is a very promising area of research.

III. Financial Economics

Applications of modern financial economics, particularly the capital asset pricing model (CAPM) and option pricing methods, have been proposed for insurance during the past fifteen years. These methods offer a novel approach to the solvency problem. Of particular interest is the emphasis on a unified view of the firm, based on both assets and liabilities.

IV. Loss Reserving

Loss reserves have a major impact on an insurer's balance sheet; they are a major determinant of surplus. Since they are estimates of future costs arising from past losses, they are subject to considerable uncertainty. Many of the works in this category aim to improve the accuracy of loss reserve estimation. Some papers treat methods for explicit provisions for adverse deviations (although these cannot currently be applied for GAAP reserves in the U.S.).

V. Statistical Methods

A number of research studies center on the utility of various systems of financial ratios and indices as predictors of continuing solvency. Many papers in this category analyze the performance of such systems based on historical data.

VI. Regulation

A primary purpose of regulation is the monitoring of the solvency of the regulated insurers. These papers discuss changes in regulation and the effectiveness of regulation.

VII. Financial Reporting and Surplus Management

Since solvency is usually understood to mean the existence of non-negative surplus, the methods used to measure surplus, the various financial reporting systems, as well as related management actions in managing surplus, will have a significant impact on the assessment of an insurer's financial condition.

VIII. Life Insurance

Recent studies, particularly in Canada and in the United Kingdom, on approaches to evaluating the solvency of life insurers and on minimum surplus requirements may have significant application to property and casualty insurers. The Canadian approach to dynamic solvency testing for life insurance companies is shortly to be extended to property and casualty insurers.

IX.   Investment Models

Solvency depends upon the entire scope of an insurer's operations, including its products and its investments. Interest rate and investment models are major components of projection simulation models; they are important in the evaluation of an insurer's solvency. Papers on asset-liability matching and investment strategy are also included here.

X.   Ratemaking

Proper product pricing, in particular the provision of adequate profit or risk margins in rates, is an important determinant of future solvency. This category has considerable overlap with category III since many recent applications of the capital asset pricing model have focused on ratemaking. In such cases, papers have often been classified under category III only.

XI.   General

In this classification are contained a number of wide-ranging papers which span many of the previous categories but do not fit easily into any of them.

2.   REVIEW OF SIGNIFICANT APPROACHES TO SOLVENCY STUDIES

The primary aim of this study is to summarize and categorize methods to study the financial condition of individual companies. One aspect is the measurement of a company's condition at a particular time. A second is the selection of leading indicators which might provide early warning of possible future difficulty. Third is the determination of necessary amounts of capital and surplus. The last, and perhaps most important, is to arrive at an understanding of all sources of risk to which the company is exposed and to have the ability to advise management as to the likely consequences for the company's financial condition of future changes in the external environment or in company strategies and operations.

A dictionary definition of solvency is "the ability to pay all just debts". Conventionally, a company is deemed solvent on the basis of its balance sheet if assets exceed liabilities. There are several caveats associated with this conventional view.

1.   Since balance sheets are usually prepared with specific frequencies, such as quarterly or annually, an outside observer can only assess the adequacy of a company's surplus at discrete times. Moreover, since the preparation of accounting statements requires considerable effort and time, such statements are usually available only after their reporting dates; the traditional view of solvency is usually retrospective.

2.	The traditional notion of solvency depends on the financial reporting system in use. There is no unique or preferred system. Many companies report on two bases: statutory, and GAAP. A third basis is used for tax purposes in the U.S. and some other jurisdictions. Moreover, the statutory systems in different jurisdictions vary considerably. A company which operates internationally and reports on multiple financial bases might have a number of markedly different views of its own financial health. It is not immediately clear which basis better portrays the ability of the company to meet its obligations.

3.	Whether a company is truly able to pay all just debts incurred depends on the current assets, investment income they will generate, the actual claim amounts to be paid in the future, and future expenses involved in handling investments, claim payments, and general administration. At any given time, most of these values are not available; we must use estimates (eg: loss reserves). This problem extends to the value of assets as well as liabilities; assets may be valued using book or market values, or something in between. Because many of these items are random variables, no reporting system will be able to identify with certainty whether a company will be able to pay all its just debts.

Even if one takes these caveats into account, it must be recognized that it is necessary to pay significant attention to the conventional accounting definition of solvency and standard financial reporting systems. In particular, a company's licence to continue doing business will depend on its meeting regulatory surplus tests calculated on a statutory basis. This is, after all, the main purpose of statutory financial reporting.

However, we are usually not concerned only with the current licence but also with the company's ability to maintain its licence. The notion of solvency takes on a dynamic or continuing nature. In the best of situations, we want to be assured that with an acceptably high degree of probability, the company will be able to meet the balance sheet solvency test at any future time.

To achieve this, one provides margins in pricing and establishes minimum surplus requirements that are intended to provide for errors in pricing, in loss reserving, and in other areas. The literature contained in this review deals with each of these to some extent.

A:	Surplus and Risk Theory

Since we are concerned with ongoing solvency, it is usually not satisfactory to require only that surplus be positive without requiring some positive minimum value for it. One minor reason is that the financial statement, and hence the determination of solvency on a balance sheet basis, is never completely up to date. Therefore, it is important to make allowance for some deterioration in the company's financial position from the reporting date until the time at which action can be taken to correct any financial problems.

A more important reason for maintaining a minimum positive value for surplus is illuminated by classical risk theory. Risk theory considers the aggregate annual losses for a block of business. This is treated as a random variable; the distribution of this variable is usually treated as a compound distribution composed of the distribution of the number of claims and the claim size distribution (distribution of claim amounts). It is important to note that this decomposition of the distribution of aggregate losses is the

5

result of having made simplifying mathematical assumptions. For an actual book of business, it is important to satisfy oneself that the underlying assumptions are at least approximately true before using the common techniques of risk theory. In order to model the distribution of the number of claims, one must assume the claim frequencies and the distribution of claim sizes have been estimated correctly. It is possible to introduce an element of uncertainty in these estimates into the model at a cost of complicating the model. The standard models and techniques for calculating them are described in standard texts which are found on the CAS examination syllabus.

A fundamental purpose of risk theory is to consider the probability that aggregate losses will exceed premium income and available surplus; this is the problem of ruin. If the time period is a single year, the problem is not too difficult to solve for the narrowly defined theoretical situations typically assumed. However, if the time period exceeds the period used in describing the number-of-claims random variable, the mathematics becomes much more complicated. In fact, approximate analytic solutions are usually available for an infinitely long time period (ruin ever). For finite time periods, with recent improvements in computing power, it is often possible to obtain numerical solutions. Since these are often not in closed form, they do not offer much insight into the underlying process.

Ruin theory attempts to give the probability of ruin or insolvency within a fixed time period depending on initial surplus, the risk loading in the premium, usually expressed as a fraction of expected losses, and the probability distribution of aggregate losses. A standard method of applying ruin theory is to choose an acceptably small probability of ruin within the time period and determine the initial surplus which will keep the probability of ruin below the desired level. In the absence of a closed solution (eg: finite time) this is quite difficult. Therefore, most applications are based on keeping the probability of ultimate ruin at a low level. Fortunately, from an actuarial point of view, this is a conservative approach since the probability of ruin in a finite time period is smaller than the probability of ultimate ruin.

As mentioned above, the calculation depends on the premium loading. The classical theory totally ignores the effect of interest or inflation. Some extensions of classical results can handle interest but are difficult to compute. There is an extension which takes policyholder dividends or experience rating into consideration; however, the mathematics is difficult and the results sometimes are counter-intuitive. For this, see the textbook by Gerber.

In short, the classical theory treats losses on future claims as the only random variable. Changes in claim frequencies and severities or the make-up of the book of business are not easily handled. Interest and expenses are usually ignored. Although it is possible to incorporate claim cost inflation into the loss distribution, this does not translate easily into the ruin situation. The theory does not treat risks associated with existing liabilities and assets. Important sources of risk such as misestimation of loss reserves, unanticipated future inflation, and adverse court decisions or changes in the law fall outside the scope of this theory. These risks are significant and must be considered when evaluating an insurer's surplus and solvency.

At best, ruin theory can give an indication of the amount of initial surplus required to maintain solvency with a desired degree of probability. This surplus will cover only the risks related to random fluctuation in total losses. It is not likely that we can base a practical method of monitoring solvency strictly on ruin theory. One recent paper which does consider the more complicated situation in a finite time interval is (Meyers, 1986).

6

A more recent development concerning surplus requirements is the emergence of risk-based surplus formulas. These are under development by NAIC and follow the introduction of similar requirements in the European Economic Community (Council of the European Communities, 1979) and, for life insurers, in Canada (Canadian Life and Health Insurance Association, 1991). The usual form of such formulas is to require, for each major source of risk, surplus equal to the product of some measure of a company's exposure to that risk and a fixed factor. For risks related to random non-systematic fluctuations in losses relating to future premium earnings, these factors may be derived using ruin theory.

Papers on this subject area are to be found under subject classification I.

B: Loss Reserving

The extensive literature on loss reserving falls outside the scope of this study. Only papers which make an explicit connection between loss reserving and solvency are included. Very few of these discuss explicit provision of margins within reserves. Among these are (Arata, 1983), (Ashe, 1986), (Byrnes, 1986), (De Jong and Zehnwirth, 1982), and (Sogn, 1984). Perhaps the most useful work in this area does not appear in the bibliography since it is still in preparation; this is the work of the Canadian Institute of Actuaries Committee on Property and Casualty Insurance Financial Reporting on provisions for adverse deviations in loss reserves. The need for this provision was studied in (Panjer and Brown, 1990). In this context, these provisions for adverse deviations are expected to cover errors due to misestimation of claim amounts and timing of claim payments. This approach may be difficult to implement in the U.S. since margins for adverse deviations cannot be included in GAAP reserves. However, the absence of discounting in these reserves may lead to an implicit provision for adverse deviations.

Papers on this subject area are to be found under subject classification IV.

C: Financial Economics

The historical impetus for rate regulation has often been taken to be the maintenance of solvency. From this point of view, the regulatory interest would appear to be avoidance of insufficient or deficient premiums. Some papers which discuss margins in this way are (Ramlau-Hansen, 1988 Part II), (Taylor, 1988), and (Martin-Lof, 1983). The bulk of the research literature in the bibliography suggests a diametrically opposed perspective. The majority of papers treat rate regulation for insurers in a manner analogous to that used for public utilities. This is particularly so for the significant body of work stemming from financial economics, reviewed below.

A sizable literature has developed on the application of financial economics, particularly CAPM and option pricing theory, to insurance. The main application has been to pricing or ratemaking. A description of these applications can be found in (Cummins, 1991). A discussion of the utility of this approach for solvency studies is found in (Daykin and Hey, 1990). In general, this approach does not give direct solvency-related information about a particular company. The emphasis in these papers is on a ratemaking procedure which will give insurers a fair rate of return on equity. Solvency enters into the discussion when the fair rate is considered. However, the risks faced by an insurer in carrying out its business are not usually explicitly considered. Solvency determination must examine the total risk of the

7

company, while most financial economic theory only examines non-diversifiable risk. The principal exception is the paper (Cummins, 1986) on risk based premiums for insurance guaranty funds; this paper attempts to put a price on a company's financial condition. This approach, if continued and refined, shows promise as an approach to solvency studies.

Perhaps the most important point to be taken from this finance literature is that solvency is a matter involving all aspects of the company, including assets, investment policy, and capital structure. In addition, financial market forces cannot be ignored. Important sources for information on asset-liability matching for insurance companies are (Platt, 1986), (Tilley, 1980), and (Boyle, 1978).

As Daykin and Hey conclude, the papers based on applications of financial economics give an alternative way of describing what is going on in the market place but are not of much direct use in analyzing the situation of a particular company, particularly when alternative courses of action are being considered.

There is, however, a possible future link between the actuarial and financial economics approaches which merits further study. Recent experience in the life insurance industry in Canada has shown that as the Minimum Continuing Capital and Surplus Requirement, a risk-based formula, has come into effect, companies have begun to use the requirement determined by each line of business (including its supporting assets) as a measure of the company's equity invested in the line; this is important in considering return on equity in pricing. If risk-based surplus requirements are introduced into other segments of the insurance industry, they would be used as one measure of the needed invested capital when doing ROI calculations. Application of methods based on financial economics, particularly option pricing theory, to ratemaking in which the goal is to produce a fair rate of return on required risk based surplus could provide useful links between pricing and the maintenance of solvency.

Papers on this subject area are to be found under subject classification III.

D: Projection Simulation Models

None of the approaches to solvency studies which have been discussed seem to offer direct application to the study of particular companies. These approaches are mathematical in nature. In order to arrive at mathematical settings which one has any hope of solving, it is usually necessary to make simplifying assumptions. While these assumptions improve our chances of obtaining answers, they also guarantee the answers will be of limited use since they ignore important aspects of the real world situation.

An alternate approach is to simulate a company by computer models. One gives up the possibility of nice analytic solutions. Thanks to recent increases in computing power at greatly reduced cost, one gains the ability to vary beginning assumptions and test the model and the company under a wide variety of scenarios of possible future experience. This approach shows great promise, given the current state of our mathematical knowledge, for studying insurers' solvency.

There are two important series of works which have developed this approach. The first comes from Finland as a series of papers by Pentikainen and his colleagues. Their work is best summarized in the book (Pentikainen, Bonsdorff, Pesonen, Rantala, and Ruohonen, 1989). The second series stems from the activities of a working party of the Institute of Actuaries in the United Kingdom, concerning the solvency of general insurance companies. This has resulted in a series of works by Daykin and his

8

colleagues. The most recent, and useful, paper in this series is (Daykin and Hey, 1990).

This modelling approach to solvency has been implemented in Canada as a professional technique under the name Dynamic Solvency Testing. The approach taken is described in (Canadian Institute of Actuaries, 1989) and (Brender, 1991). Initially, Dynamic Solvency Testing has been applied to life insurers. However, it is expected to be extended to property and casualty insurers in 1992 or 1993. This procedure forms the basis for the annual report on a company's financial condition which, under new Canadian legislation, the appointed actuary must make to the board of directors for both life and property and casualty insurance companies.

An important question in adopting the simulation approach is the length of the projection period. There is a temptation to consider the property and casualty business as short term, and therefore not requiring extensive projections. However, there is broad recognition that the industry is subject to underwriting cycles of the order of five to eight years. Moreover, times to settlement of claims are often very long, exposing insurers to significant inflation risk and other estimation error. These observations suggest projections must be done for a period at least as great as a typical underwriting cycle; a ten year projection would not appear to be excessive.

Projections are usually carried out using different scenarios of possible future experience and management decisions. One must consider whether these scenarios will be deterministic or stochastically generated. Both the Finnish and British groups have taken a stochastic approach. A fundamental stochastic element has been the model which generates the economic assumptions. Both groups have used the basic approach of (Wilkie, 1986). On the other hand, the Canadian Dynamic Solvency Testing process uses deterministic scenarios. In principle, the stochastic approach is preferable. However, if its results are to be relied on in operating actual companies, one must be assured that the models used to generate scenarios do in fact accurately reflect our real environment. It can be argued that the Wilkie model does not meet this condition in the United Kingdom (Geoghegan et al, 1992); it certainly does not describe the situation in North America without modification. Work is in progress in this area on a number of fronts. If the stochastic simulation approach to solvency is adopted, it will be necessary for (North American) actuaries to undertake considerable work in models for generating scenarios. It should also be noted that simulation models generally produce voluminous numerical results. When many scenarios are run, the results can be overwhelming. Methods of analyzing these results to make them comprehensible will require further development.

The advantage of the deterministic scenario approach is that sensitivities to specific changes in variables can be assessed. For example, one can address the question "Can the company withstand a 3% increase in inflation (and the likely resulting increase in interest rates)?". This approach does not produce probabilities of ruin as does the stochastic scenario approach. However, without a lot of detailed work, the stochastic scenario approach does not identify the causes of insolvency.

Papers on this subject area are to be found under subject classification II.

E: Ratio Tests

Those in the insurance industry are familiar with a number of financial ratio tests which are used as

9

'quick and dirty' indicators of a company's financial condition. Most important in this category is the NAIC's IRIS system. Certain indicators used by various rating agencies are also of this type. Several papers study the effectiveness of these tests (Ambrose and Seward, 1988), (Bar-Niv and Hershbarger, 1988), (Pinches and Trieschmann, 1974). Although these tests may appear to be rather crude when compared with the information which can be obtained from simulation models, nevertheless they will probably always be with us. There is a genuine need, particularly on the part of regulators, for tests based on current, and usually public, financial data. It seems that it would be profitable to improve on the tests currently in use. Possible approaches are suggested in (Harrington and Nelson, 1986), (Ludwig and McAuley, 1988) and (Salzmann, 1981). The multivariate discriminant analysis approach, as described, for example, in the works by Altman listed in the bibliography, seems to be promising in this regard.

Papers on this subject area are to be found under subject classification V.

RISK THEORY TEXTS

BEARD, R.E., PENTIKAINEN, T., PESONEN, E., *Risk Theory* third edition, Chapman and Hall, London, 1984

BUHLMANN, HANS, *Mathematical Methods in Risk Theory*, Springer-Verlag, Berlin, 1970

GERBER, HANS U., *An Introduction to Mathematical Risk Theory*, S.S. Huebner Foundation for Insurance Education, Richard D. Irwin Inc., Homewood, 1979

PANJER, H.H., WILLMOT, G.W., *Insurance Risk Models*, Society of Actuaries, Schaumberg, 1992, to appear

SEAL, HILARY L., *Stochastic Theory of a Risk Business*, John Wiley & Sons, New York, 1969

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NOTE: In addition to the papers contained in this bibliography, the reader should also
consult the two-volume set *Insurer Financial Solvency*, the proceedings of the 1992
CAS Discussion Paper Program in Chicago.   These papers appeared after this
bibliography was prepared.

APPENDIX B

Papers listed by subject

B - I

Papers on Classical Risk Theory

BACHMAN, J.E. "Capitalization Requirements for Multiple Line Property – Liability Insurance Companies". Huebner Foundation Monograph, University of Pennsylvania 1978.

The author considers product line combinations and capitalization requirements. He uses a general random walk model to determine the amount of capital required to preserve solvency over various time horizons within a given level of probability. The study concludes that a uniform ratio of premium to surplus cannot be applied on an industry-wide basis, and also that the composition of the investment portfolio has a major effect on solvency, in fact greater than underwriting activity alone. Thirdly, the study concludes that an insurer can increase its premium-surplus ratio without increasing its probability of ruin merely by changing its insurance product line mix. A combination of a high premium-surplus ratio and an all bond portfolio offers a greater expected total rate of return and a smaller probability of ruin (and hence requires less capital) than the combination of a low premium-surplus ratio and an investment portfolio which emphasizes common stocks.

BOHMAN, H. "Rule of Thumb for the Determination of a Sufficient Risk Reserve". Scandinavian Actuarial Journal (1974) 237-240.

The author suggests a heuristic method based on a random walk method to determine the probability that the risk reserve is non-negative at the end of the planning period and for arbitrarily many discrete intermediate points.

BOHMAN, H. "Solvency and Profitability Standards". Scandinavian Actuarial Journal (1976) 111-113.

The author defines a solvency standard and profitability standard. He then solves the following problem: Under what conditions can a new contract be added to a portfolio that contains only profitable contracts? He shows that if the new contract is profitable, then the expanded portfolio will also be profitable, but the existing reserve must be great enough to accommodate the new contract, in order for the expanded portfolio to remain solvent.

BROWN, A. "Insuring the Solvency Margin of a Capital Guaranteed Fund". Transactions of the International Congress of Actuaries (1988).

A simple model is constructed of a capital guaranteed fund. The probability that the solvency margin falls below a specified level is calculated from this model. The cost of insuring the solvency margin on a stop-loss basis can be determined from the probabilities. The maximum net return on the assets after allowing for this insurance indicates an appropriate investment strategy.

CUMMINS, J.D. "Statistical and Financial Models of Insurance Pricing and the Insurance Firm". Journal of Risk and Insurance 58 (1991) 261-302

The author tries to reconcile the actuarial and the financial models of insurance, beginning with the idea of insurance pricing. He gives a brief background of statistical models of insurance, based on risk theory; then he gives a brief background to financial models of insurance, based on CAPM. Then he lists five areas where the integration of statistical and financial models would be valuable:

(1) the development of asset/liability management models that take into account more sophisticated models of the reserve run-off,

(2) financial models of reinsurance using option pricing theory, taking into account the fact that insurance claims are non-traded assets, and using probability distributions other than the lognormal,

(3) development of multiperiod option pricing models for long-tail insurance contracts, instead of using a funds generating or "k" factors approach to model the claims runoff process,

(4) adaptation of pricing and asset/liability management models to incorporate stochastic interest rates,

(5) endogenization of surplus.

MEYERS, G. "Equilibrium in the Capital Structure of an Insurance Company". International Conference on Insurance Solvency I, 1986

This paper uses finite ruin theory to predict the amount of surplus that will support a given rate of return. This calculation takes into account many relevant factors such as the size of the company, characteristics of the lines of insurance written by the company, parameter uncertainty, excess of loss insurance and investment income. Particular attention is paid to uncertainty in loss reserves, security loads and the underwriting cycle.

16

PENTIKAINEN, T., RANTALA, J. "Solvency of Insurers and Equalization Reserves". Vol. I (General Aspects), Vol. II (Risk Theoretical Model), Insurance Publishing Company Ltd. 1982, Helsinki

This is a research report under the directorship of T. Pentikainen, proposed for the Insurance Department of the Ministry of Social Affairs and Health of Finland. The following topics are discussed:

Vol. I

(1) solvency politics and background factors,

(2) empirical data,

(3) risk-theoretical model,

(4) solvency ratios,

(5) solvency margins,

(6) measuring solvency,

(7) fluctuation reserve.

Vol. II

(1) distribution of total claim amount,

(2) stochastic dynamic model of insurance company,

(3) analytic treatment of model,

(4) fluctuation range of solvency margin, minimum safety loadings and solvency test,

(5) simulation of total claims caused by catastrophes,

(6) reinsurance, solvency margin and policyholders,

(7) regulation of equalization reserves of Finnish non-life insurers.

PENTIKAINEN, T., BONSDORFF, H., PESONEN, M., RANTALA, J., RUOHONEN, M. "Insurance Solvency and Financial Strength". Finnish Insurance Training and Publishing Company Ltd., 1989, Helsinki

This book gives a general survey of the subject matter, and tries to bridge the gap between theory and practice i.e. between academicians and practicing actuaries. The book covers the areas of risks and effects, including claims, business cycles, premiums, investment return and asset risks, expenses, taxes, dividends, and inflation. The authors also discuss public solvency control and financial strength as an element in insurance management. A simulation model is described and an explicit example is worked out using this model. The authors also discuss international regulatory issues. The text is self-contained with most of the risk-theoretic analysis following the lines of "Risk Theory" by Beard, Pentikainen, E. Pesonen.

RAMLAU-HANSEN, H. "A Solvency Study in Non-Life Insurance Part I". Scandinavian Actuarial Journal (1988) 3-34

This paper describes a study of statistical analyses of policy and claims data of a portfolio of fire, windstorm, and glass liabilities of single family houses and dwellings. Claim frequencies and claim size distributions are estimated, and the results are used to derive moments of the annual claim amounts and to provide examples of solvency margin requirements for different classes of business.

RAMLAU-HANSEN, H. "A Solvency Study in Non-Life Insurance Part II". Scandinavian Actuarial Journal (1988) 35-59

This paper shows how the solvency margin depends on portfolio composition and volume, reinsurance, time horizon, probability of ruin, and the values of some of the basis parameters. The results show that 8-28% of premium income is necessary to cover the random fluctuations in claim costs. However, statutory requirements should be higher (25-43%) to provide reasonable protection against inadequate safety loadings.

SEAL, H.L. "Simulation of the Ruin Potential of Non-life Insurance Companies". Transactions of the Society of Actuaries 21 (1969) 563-590

A simplified stochastic model of a casualty insurance company consists of two independent and unchanging probability distributions. The first of these is the distribution of intervals between successive claims, and the second is the distribution of individual claim amounts. Financially, the company may be pictured as accumulating a steady flow of risk-loaded premiums in its risk reserve and paying claims therefrom at intervals determined by the first distribution and in amounts determined by the second. This model was used to run a computer simulation of ten randomly chosen companies over a forty year period. All the companies commenced business with a fairly substantial risk reserve, but several failed during the period, even though they charged theoretically correct pure premiums. Standard experience-rating methods were found to be a poor protection against adverse change fluctuations whose cumulative effects were often substantial.

SHAKED, I. "Measuring Prospective Probabilities of Insolvency: An Application to the Life Insurance Industry". Journal of Risk and Insurance 52 (1985) 59-80

The author calculates the probability of failure of several publicly traded life insurers. These probabilities are derived by assuming that asset returns are lognormally distributed and then calculating the parameters of that distribution for each insurer. As indicated by the findings, most life insurers are reasonably safe. However, the distribution of failure probability is skewed, so that several life insurers pose a large enough insolvency risk to warrant regulatory attention. In addition, the paper examines the sensitivity of insolvency risk to the estimated parameters of the basic framework. 18

SUGARS, E.G. "A Risk Theoretic Prescription for Regulated Ratemaking". Journal of Risk and Insurance" 39 (1972) 475-478

The author suggests a method, based on risk theory, for determining a fair rate of return in the non-life insurance business. The paper contains the idea that rates should be loaded only enough to allow the insurer a fair return on that part of policyholder surplus funds required to run a prudent insurance business.

SUGARS, E.G. "Selected Results from a Risk-Theoretic Simulation of an Insurance Company". Journal of Risk and Insurance 41 (1974) 221-228

The discussion studies the consequences of complying with the one-to-one solvency rule as opposed to adhering to a 0.001 ruin criterion. In four of the five cases studied the 0.001 criterion yields distinctly different consequences for policyholders, shareholders or both. The fifth case permits an indefinitely large premium volume with comparable results for both criteria.

TAPIERO, C.S., ZUCKERMAN, D., KAHANE, Y. "Optimal Investment-Dividends Policy of an Insurance Firm under Regulation". Scandinavian Actuarial Journal (1983) 65-76

An insurance decision model including intervention by a regulating agency is defined. The insurance firm's problem is to establish an investment policy as well as a dividend strategy. Regulation is exercised by a minimal barrier policy for cash holding and penalties for violating this barrier. The joint Insurance Firm-Regulating Agency problem is discussed by using concepts from Stackleberg strategies in game theory. As in the classical model of collective risk theory it is assumed that premium payments are received deterministically from policyholders at a constant rate, while the claim process is compound Poisson. A diffusion approximation is used in order to obtain tractable results for a general claim size distribution.

19

B - II

Papers on Projection Simulation Models

BALZER, L.A., BENJAMIN, S. "Dynamic Response of Insurance Systems with Delayed Profit/Loss – Sharing Feedback to Isolated Unpredicted Claims". Journal of the Institute of Actuaries 107 (1980) 513-528

A mathematical model of the dynamic behaviour of an insurance system with delayed profit/loss sharing feedback is developed. The model is then subject to a disturbance input consisting of an isolated group of unpredicted claims and the dynamic responses of cash flow and accumulated cash flow determined. Increasing delays are seen to lead first to undesirable oscillatory responses and eventually to instability, where the responses become unbounded. Such behaviour is noted to be independent of the type of business and to be a property of the feedback mechanism and not related to the type of disturbance input.

BALZER, L.A. "Control of Insurance Systems with Delayed Profit/Loss – Sharing Feedback and Persisting Unpredicted Claims". Journal of the Institute of Actuaries 109 (1982) 285-316.

The profit/loss sharing scheme introduced by Balzer & Benjamin (1980) has been subjected to further analysis, which gives greater insight into its dynamic behaviour. Under the more demanding disturbance of a persisting stream of unpredicted claims, a significant non-zero accumulated cash flow is found to accrue after steady state conditions are reached. The dynamic behaviour was then investigated using the root-locus technique and improved. The addition of integral action was seen to drive the steady state value of the accumulated cash flow to the desirable value of zero. Finally, derivative action was shown conclusively to offer no improvements due to the time delay present in the system.

21

CANADIAN INSTITUTE OF ACTUARIES "A Primer on Dynamic Solvency Testing", 1989

This paper describes in detail the two main steps in the DST process, namely the projection of surplus trends, and modeling. The projection component is carried out as follows:

(1) calculate historical patterns of actual free surplus and the corresponding required amounts for the most recent three-year period,

(2) project these calculations forward for five years using best estimates of experience and business plans of the company,

(3) recalculate the five-year projections on a set of 10 prescribed scenarios, each of which focuses on a specific single potentially adverse trend in experience,

(4) recalculate the same five-year projections on additional appropriate combination of adverse trends, so as to provide adequate information to management on the hypothetical, plausible and significant threats to the company's financial well-being.

The first scenario tested has the future experience projected based on the best estimates of each relevant factor. This is known as the base scenario. Subsequent scenarios are defined by making prescribed changes in the following areas: mortality, morbidity, withdrawals, increasing interest rates, decreasing interest rates, level new sales, high new sales, sudden high mortality and morbidity, increased default rates, expense rates.

The modeling component of DST involves the development of algorithms to simulate future events, and the selection of cells, or representative blocks of policies and assets which reflect the company's actual portfolio. One possible modeling technique is the projection of gains (or margins) by source. Another possibility is extrapolation in aggregate, meaning that financial statements are projected by studying recent trends in aggregate data for the product line to be projected. The political and economic environment of business must also be considered in the modeling process. Finally, the model must be sufficiently flexible to reflect the variability of the real world.

COUTTS, S.M., DEVITT, E.R.F., ROSS, G.A. "A Probabilistic Approach to Assessing the Financial Strength of a General Insurance Company". Transactions of the International Congress of Actuaries (1984).

This paper develops a conceptual framework for measuring the financial strength of a non-life insurance company from a supervisor's point of view; that is, it looks at the financial information at a point of time and assumes that company ceases trading. However the paper does not adopt the conventional approach of looking just at the balance sheet values, but argues that a more realistic answer is obtained if projected run-offs for assets and liabilities are modelled. The framework takes account of not only assets, liabilities, and economic risk, but also acknowledges the micro and macro aspects of these. An algorithm is given to arrive at a measure of financial strength by employing simulation techniques. This uses the present asset holdings, a probabilistic model to predict future asset values and investment income together with a set of decision rules for investment strategy, and bivariate probability distribution of claim payments by amount and time.

COUTTS, S.M., DEVITT, E.R.F. "The Assessment of the Financial Strength of Insurance Companies by a Generalized Cash Flow Model". International Congress on Insurance Solvency I, 1986.

The central concept of this paper is that the subject of financial solidity within the insurance industry can be dealt with in terms of one integrated model which is applicable to all types of insurance operations. The authors believe that the correct way to approach the determination of the financial strength of an insurance company is to look in terms of the relationship between the projected cash inflows and outflows. Since the projection of future cashflows cannot be made with certainty, these streams of future income and outgo must be modelled. Any realistic model must take account of the variability inherent in such predictions and a practical way to address this problem is through the use of simulation techniques.

COUTTS, S.M., DEVITT, E.R.F. "Simulation Models and the Management of a Reinsurance Company". Transactions of the International Congress of Actuaries (1988).

This paper rejects the traditional balance sheet approach to the measurement of solvency and capital strength of an insurance company in favour of an emerging costs approach. It discusses the particular problems of modeling future cash flows of a reinsurer and suggests solutions for some of them. It sets out an algorithm for the measurement of a reinsurer's capital strength and summarizes the advantages of the emerging costs approach.

23

DAYKIN, C.D., BERNSTEIN, G.D., COUTTS, S.M., DEVITT, E.R., HEY, G.B., REYNOLDS, D.I.W. and SMITH, P.D. "The Solvency of a General Insurance Company in Terms of Emerging Costs". Astin Bulletin 17 (1987) 85-132.

The authors challenge the traditional balance sheet concept of solvency of a general insurance company and put forward an emerging costs concept which enables the true nature of assets and liabilities to be taken into account, including their essential variability. A simulation model is used to explore various aspects of the company's financial position. It suggests the need for an appropriate asset margin assessed individually for each company. The effectiveness of supervision based on the balance sheet and a crude solvency margin is limited. More responsibility should be placed on an actuary or other suitably qualified professional to report on the overall financial strength of the company, both to management and to supervisory authorities.

DAYKIN, C.D. "Handling Uncertainty in Examining the Financial Strength of a General Insurance Company". Transactions of the International Congress of Actuaries (1988).

The traditional balance sheet approach to the assessment of financial strength of a general insurance company offers limited scope for exploring the effects of uncertainty. An alternative approach is to project the cash flow in future years and to use stochastic models to represent the uncertain factors. A model developed along these lines is described and some results presented. The wide variation in the risk of ruin according to the precise circumstances of the company points to the need for actuarial reports on the financial strength of general insurance companies. Simulation models provide a technique which could be used for such reports, enabling the key assumptions to be made explicit.

DAYKIN, C.D., HEY, G.B. "A Management Model of a General Insurance Company Using Simulation Techniques". International Conference on Insurance Solvency II, 1988.

The accounts of a general insurance company are not drawn up in such a way as to bring out the uncertainties involved in making an assessment of a company's financial strength or of its future profit earning capacity. An analysis of the possible emergence of profit in future years, and the development of the balance sheet, implies the ability to model the way in which the various items in profit and loss account and the balance sheet will behave in uncertain conditions. An approach to the analysis of such uncertainty using cash flows, or emerging costs, was described by Daykin et al. (1987) as an effective alternative to the traditional balance sheet approach. The purpose of this paper is to translate the concepts of the earlier paper into the framework of a company assessed as a going concern, where business can be assumed to continue to be written for the forseeable future.

DAYKIN, C.D., HEY, G.B. "Modeling the Operations of a General Insurance Company by Simulation". Journal of the Institute of Actuaries 116 (1989) 639-662.

A cash flow model is proposed as a way of analyzing uncertainty in the future development of a general insurance company. The company is modelled alongside the market in aggregate so that the impact of changes in premium rates relative to the market can be assessed. An extensive computer model is developed along these lines, intended for use in practical applications by actuaries advising the management of general insurance companies. Simulation methods are used to explore the consequences of uncertainty, particularly in regard to inflation and investments. Some comments are made on the role of actuaries in general insurance. Alternative approaches to describing the behaviour of an insurance firm in the market are considered.

DAYKIN, C.D., HEY, G.B. "Managing Uncertainty in a General Insurance Office". Journal of Institute of Actuaries 117 (1990) 173-277.

The authors use the emerging costs paradigm to assess the future financial strength of an insurance company. A model is devised which characterizes the pattern of inflows and outflows at any time. An important aspect of the model is the variability of future assets, for which Wilkie's results were extensively used. The model was generalized to the situation of a company operating as a going concern. The generalized model represents the behaviour of the company as it operates in the wider market. It considers premium and investment income, claims and expense costs, as well as taxes and dividends. However, reinsurance is not considered.

DAYKIN, C.D., HEY, G.B. "Applications of a Simulation Model of a General Insurance Company". International Conference on Insurance Solvency III, 1991.

A simulation model of a general insurance company has already been presented by the authors at various stages of its development. In this paper a general description of the model is given and some results are presented from using the model to explore a variety of different scenarios. The model is based on the emerging costs paradigm. Important features of the business can be taken into account in as realistic a way as possible, including tax and dividend payments, as well as premium income expenses, claim outgo, investment income, asset values, and investment strategy. At a more sophisticated level, appropriate allowance can be made for feedback mechanisms and for interactions between the variables. Uncertainty can be modelled directly. The results of some calculations for given distributions are then presented and it is shown that government regulation may still be necessary.

25

DAYKIN, C.D., BERNSTEIN, G.C., COUTTS, S.M., DEVITT, E.R.F., HEY, G.B., REYNOLDS, D.I.W., SMITH, P.D. "Assessing the Solvency and Financial Strength of a General Insurance Company". Journal of the Institute of Actuaries, 114 (1987) 227-325.

The authors put forward an emerging costs approach for examining the strength of a company. Simulation is suggested as a means for examining the financial strength of a company and exploring the impact of alternative scenarios. A particular example of such a simulation model is presented and used to explore the resilience of a company's financial position to variations in a wide variety of parameters. The model enables the user to quantify the probability that the assets will prove adequate to meet the liabilities with or without an assumption of continuing business. This in turn permits an appropriate asset margin to be assessed individually for any particular company in the light of the strategy that the company intends to follow. Some of the implications of this approach for the management and supervision of general insurance companies are reported.

DAYKIN, C.D., DEVITT, E.R.F., KHAN, M.R., McCAUGHAN, J.P. "The Solvency of General Insurance Companies". Journal of the Institute of Actuaries 111 (1984) 279-336.

This paper tries to establish a framework for consideration of solvency of a general insurance company, particularly from the point of view of whether a company has adequate resources to continue to write business. Attention is focussed on the importance of setting adequate standards of prudence for technical reserves. The authors investigate variability as it affects the assets side of the balance sheet and conclude that mismatching reserves should be included in the technical reserves and that an element of the solvency margin should be required to provide against this risk. A conceptual framework is drawn up for setting the line of demarcation between technical reserves and the solvency margin. The report concludes with some pointers to a possible reserving standard embracing concepts of variability which could form the basis for a more satisfactory system of reporting technical reserves from the point of view of demonstrating solvency and suggests a rational approach to the appropriate level for statutory solvency margins, having regard to the nature of the risks and the possible variability of the out-turn.

FRANCIS, L.A. "A Model for Combining Timing, Interest Rate, and Aggregate Loss Risk". Valuation Issues Special Interest Seminar, Casualty Actuarial Society, 1989, 155-216.

Models are developed to simultaneously analyze timing risk, investment return uncertainty, and aggregate loss variability. These are based on collective risk theory, payment pattern regressions, and time series stochastic models for interest rates. An application to the calculation of capital requirements for a capture insuring automobile liability is described. A second application is to modelling capital requirements for the medical malpractice line.

GALITZ, L. "The ASIR Model – An Introduction". The Geneva Papers on Risk and Insurance No. 25 (Oct. 1982)

This paper describes the development of the ASIR model for simulating insurance and reinsurance operations. The model can be run either deterministically, or stochastically, depending on the application. Next, the model is descriptive rather than optimizing, and uses an accounting rather than empirical approach. Two examples of research studies are given, one for the effect of inflation on interest rates, and the other concerning fluctuating exchange rates.

GENTRY, J.A. "Simulation of the Financial Planning Process of P-L Insurers "Journal of Risk and Insurance 39 (1972) 383-396.

The author develops a model that simulates the long run financing process of property and liability insurance companies. A key variable determined by the model is the rate of return required on new investments in order to produce management's desired earnings per share growth objective. Thus, the model links the investment and financing processes of property and liability insurance companies and provides decision makers probabilistic oriented information for analyzing investment alternatives.

HEY, G.B., BERNSTEIN, G.D. "Simulating the Cash Flow of a General Insurer". Transactions of the International Congress of Actuaries (1988)

This paper describes extensive simulation work carried out by the authors for the Solvency Working Party of the General Insurance Studies Group of the Institute of Actuaries. The program projects the cash flows of an insurer from a given date, being the date at which its solvency is being investigated to a time in the future when all of its liabilities have been run off. The program can allow for a period during which new business continues to be written. It also allows for variations in the claim amounts (in real terms), claim inflation, future investment income, assets charges, tax and dividends. The initial portfolio of assets and liabilities is taken as given.

NYE, D.J. "A Simulation Analysis of Capital Structure in a Property Insurance Firm". Huebner Foundation Monograph, University of Pennsylvania, 1975

The purpose of this study was two-fold: first, to measure the effect of capital structure on three variables – ruin probability, rate of return on equity, and variability of return; and second, to further the development of quantitative criteria which could be utilized by regulatory officials to supervise property insurance companies and by management in the development of long-term plans. Using simulation techniques, experiments were performed on two types of firms, one an established, ongoing firm, and the other a new firm entering the market. In both cases, firms were restricted to automobile insurance. A novel aspect of this study is the use of senior securities as a financing device.

PAULSON, A.S., DIXIT, R. "Cash Flow Simulation Models for Premium and Surplus Analysis". International Conference on Insurance Solvency I, 1986

This paper summarizes some typical results generated from a set of general cash flow simulation models which were produced to mimic a statutory insurance company operating in a general economic environment. The flows resulting from the underwriting and investment sides of the business are treated in an integrated and dynamic fashion. A large number of economic, company-specific, tax-specific, surplus-specific, and other factors are allowed in these models. Several results concerning the influence of size of underwriting firm, combined ratio, variability of losses, impairment of capital, and probability of insolvency, are given.

PENTIKAINEN, T. "A Model of Stochastic-Dynamic Prognosis". Scandinavian Actuarial Journal (1975) 29-53

The article develops the different phases in the process of managing an insurance business:

(1) information of the state and past development of the business,

(2) decisions needed,

(3) long range planning by means of prognosis,

(4) business goals, which include:

   (a) solvency,

   (b) maximization of profit or dividends,

   (c) expansion of the business.

A mathematical model is developed, with most of the ideas drawn from Beard, Pentikainen, Pesonen, "Risk Theory". The author then makes some simplifying assumptions to apply the general model to a specific example.

PENTIKAINEN, T. "Stochastic-Dynamic Prognosis". Transactions of the International Congress of Actuaries (1976)

A model is constructed which describes the state of an insurance company as well as the rules for decision making. The future flow of business depends, in addition to the strategy chosen, also on stochastic elements such as the amount of claims. It is possible to calculate the limits of the state parameters, free reserves, premiums, etc. at any future time point by a given probability, as well as to evaluate the risk of ruin. Different strategies can be compared in this way and an optimal one arrived at. A simple numerical application is given.

PENTIKAINEN, T. "A Solvency Testing Model-Building Approach for Business Planning". Scandinavian Actuarial Journal (1978) 19-37

The purpose of this paper is to incorporate stochastic elements into business models using techniques which have been developed in risk theory for the evaluation of risk fluctuations. Some applications concerning competitive business strategies are presented. This method allows various goals to be pursued, subject to a solvency indicator remaining within predetermined constraints. Some results are given from simulation experiments concerning solvency testing.

PENTIKAINEN, T., RANTALA, J. "Evaluation of the Capacity of Risk-Carriers by Means of Stochastic-Dynamic Programming". Astin Bulletin 12 (1981) 1-21

The problem of capacity of risk carriers is treated by means of

(1) an empirical approach observing actual fluctuations in underwriting gains of insurers,

(2) a theoretical approach, constructing a stochastic-dynamic model and studying its behaviour, especially its sensitivity to numerous background factors.

The methods of investigation are described and their application is then demonstrated using some numerical data. Consideration here is limited to stochastic risks, omitting the fact that the solvency of an insurer is also jeopardized by numerous "non-stochastic" risks, such as investment failure, etc.

PENTIKAINEN, T., RANTALA, J. "Solvency of Insurers and Equalization Reserves". Vol. I (General Aspects), Vol. II (Risk Theoretical Model), Insurance Publishing Company Ltd. 1982, Helsinki

This is a research report under the directorship of T. Pentikainen, proposed for the Insurance Department of the Ministry of Social Affairs and Health of Finland. The following topics are discussed:

Vol. I

    (1)   solvency politics and background factors,

    (2)   empirical data,

    (3)   risk-theoretical model,

    (4)   solvency ratios,

    (5)   solvency margins,

    (6)   measuring solvency,

    (7)   fluctuation reserve.

Vol. II

    (1)   distribution of total claim amount,

    (2)   stochastic dynamic model of insurance company,

    (3)   analytic treatment of model,

    (4)   fluctuation range of solvency margin, minimum safety loadings and solvency test,

    (5)   simulation of total claims caused by catastrophes,

    (6)   reinsurance, solvency margin and policyholders,

    (7)   regulation of equalization reserves of Finnish non-life insurers.

PENTIKAINEN, T., RANTALA, J. "Run-off Risk as a Part of Claims Fluctuation". Astin Bulletin 16 (1986) 113-147

The purpose of this paper is to discuss how the run-off risk could be incorporated into the standard risk theory model as a separate entry, and to find some evaluation of the order of magnitude of the extra fluctuation so rendered. At this stage of the research, the impact of parametric estimation is excluded from consideration. Therefore, the results and numerical examples do not describe the total uncertainty of claims or reserves. The authors study both the going-concern case, and the break-up case. They also use a simulation technique, which allows for more general assumptions about inflation.

PENTIKAINEN, T., PESONEN, M. "Stochastic Dynamic Analysis of Life Insurance". Transactions of the International Congress of Actuaries (1988)

The authors treat the life insurance business as a stochastic process consisting of the flow of entering, developing and terminating cohorts of policies. The exemplified model allows for the stochastic fluctuation of mortality, inflation and interest, and the process is controlled by the delivery of bonuses and/or dividends according to the simulated financial position. The benefits and premiums can be linked to the cost of living index. The model is aimed to be used in analyzing solvency conditions and the adequacy of safety loadings that are included in the calculation bases of premiums and reserves.

PENTIKAINEN, T., BONSDORFF, H., PESONEN, M., RANTALA, J., RUOHONEN, M. "Insurance Solvency and Financial Strength". Finnish Insurance Training and Publishing Company Ltd., 1989, Helsinki

This book gives a general survey of the subject matter, and tries to bridge the gap between theory and practice i.e. between academicians and practicing actuaries. The book covers the areas of risks and effects, including claims, business cycles, premiums, investment return and asset risks, expenses, taxes, dividends, and inflation. The authors also discuss public solvency control and financial strength as an element in insurance management. A simulation model is described and an explicit example is worked out using this model. The authors also discuss international regulatory issues. The text is self-contained with most of the risk-theoretic analysis following the lines of "Risk Theory" by Beard, Pentikainen, E. Pesonen.

RANTALA, J. "Method for the Analyzing the Effects of Underwriting Risk on the Insurers Long-Term Solvency". International Conference on Insurance Solvency I, 1986

The aim of this paper is to develop further the ideas put forward in the Finnish solvency report (Pentikainen, Rantala, 1982), and to provide a framework for analyzing how the insurers' solvency is affected by the underwriting risk. The focus is primarily on long-term relations and properties. The insurer is viewed as a filter transforming the claims process, the most important outputs being claims reserve, accumulated profit and the future premium rates. Main points of interest are the variability of both premiums and accumulated profit and the long term need for the safety loading where the rating rules are applied. The methods of time series theory and stochastic control theory are utilized. Also, a practical example is considered.

REYNOLDS, D.I.W., SMITH, P.D. "Changes in the Probability of Insolvency – Results from A General Insurance Simulation Model". Transactions of the International Congress of Actuaries (1988)

A simulation model is used to investigate how the probability of insolvency changes in response to random movements in asset values, inflation, claims settlement amounts and claims experience on new business. Rates of inflation above expected values cause the greatest increase in the chance of insolvency. The authors suggest that investment in index-linked securities would

31

therefore be appropriate for U.K. insurance companies.

ROY, Y., CUMMINS, J.D. "A Stochastic Simulation Model for Reinsurance Decision Making by Ceding Companies". Strategic Planning and Modeling in Property-Liability Insurance (ed. Cummins) 1985, Kluwer-Nijhoff, Boston

This study develops a prototype model which applies to the fire and earthquake risks of a hypothetical company. A computer model is designed to simulate the financial results the company would experience under various reinsurance arrangements. The model generates the company's probability distributions of net worth and net income under alternative reinsurance strategies, permitting management to select an optimal arrangement by comparing the resulting distributions.

RYAN, J.P. "An Application of Model Office Techniques to the Solvency Question". Transactions of the International Congress of Actuaries (1980)

A computer simulation is described which shows the resulting distribution of solvency margins after 5 years for companies making varying levels of profits. The programme enables simulation of both claims experience and investment experience. The claims experience allows for stochastic variation as well as random inflation. The investments are in the form of equities and fixed interest. The interest rates are determined relative to the inflation rate, with no random variation. However, stock prices are determined using a random walk model.

RYAN, J.P. "Application of Simulation Techniques to Solvency Testing for a Non-life Office". Transactions of the International Congress of Actuaries (1984)

The paper outlines a stochastic approach which analyzes the various risks (including investment) to solvency. The paper discusses the problem of lack of independence of risk and parameter variation over time as well as any correlations between results of different classes of business. The paper concludes by showing how such an analysis can be used to determine capital requirements of a company in relation to different business strategies including variations in investment policy.

SEAL, H.L. "Simulation of the Ruin Potential of Non-life Insurance Companies". Transactions of the Society of Actuaries 21 (1969) 563-590

A simplified stochastic model of a casualty insurance company consists of two independent and unchanging probability distributions. The first of these is the distribution of intervals between successive claims, and the second is the distribution of individual claim amounts. Financially, the company may be pictured as accumulating a steady flow of risk-loaded premiums in its risk reserve and paying claims therefrom at intervals determined by the first distribution and in amounts determined by the second. This model was used to run a computer simulation of ten randomly chosen companies over a forty year period. All the companies commenced business

with a fairly substantial risk reserve, but several failed during the period, even though they charged theoretically correct pure premiums. Standard experience-rating methods were found to be a poor protection against adverse change fluctuations whose cumulative effects were often substantial.

TAPIERO, C.S. "A Dynamic Insurance Firm Model and Dividend Optimization". Journal of Large Scale Systems 9 (1985) 19-33

The purpose of this paper is twofold. First, to formulate a dynamical model of a stock insurance firm and, second, to solve the insurance firm problem (in terms of its loading factor, investment-disinvestment and dividend policies), granted that its objective is (discounted) dividend maximization. The mathematical problem defined is a two-states stochastic control problem which is solved and interpreted to yield insights regarding the management of insurance firms.

TRIESCHMANN, J.S., DAVIS, K.R., LEVERETT, E.J. "A Probabilistic Valuation Model for a Property-Liability Insurance Agency". Journal of Risk and Insurance 42 (1975) 289-302

This model uses Monte Carlo simulation and discounted cash flow analysis. The model allows one to look at fluctuating levels of expenses and commissions. The results show that the old rule of thumb gross commission method of valuation tends to produce valuations that are too high. Sensitivity analysis shows that the most important variables for valuation purposes are number of years of upgrading commissions, selling and operating expenses, and persistency of year before purchase commissions. The variables that have the least effect are change in accounts payable, change in accounts receivable, and rate of inflation.

VEIT, K.P. "The Use of Systems Dynamics Simulation Models for Corporate Long Range Strategic Planning". Transactions of the International Congress of Actuaries (1976)

The paper contrasts systems dynamics models in general with the more traditional asset share and profit models with which most North American actuaries are familiar. The major benefits of using this type of model are:

(1) the ability to handle multiple inter-relationships and complex feedback loops where a large number of variables are interacting with each other over time,

(2) the ability to handle variables with largely subjective values,

(3) the better understanding of how one's own organization really functions which arises out of the model construction process.

WATERS, H.R. "Some Aspects of Life Assurance Solvency". International Conference on Insurance Solvency I, 1986

This paper uses a stochastic investment model developed by A.D. Wilkie to study in probabilistic terms the investment risk to the solvency of a life assurance company. Two probabilities are

33

considered for a cohort of policies:

    (i)   the probability that the premium paid together with investment income and any initial reserve will be insufficient to pay for the claims,

    (ii)   the probability that at any time during the term of the policies the investment experience will have been sufficiently bad for a valuation to produce a deficit.

These probabilities are studied numerically for different investment strategies.

B - III

Papers on Financial Economics

ASHE, F. "Non-Parametric Analysis of Asset-Liability Management". International Conference on Insurance Solvency III, 1991.

The paper considers the asset-liability management of a major-class of insurance and super annuation contracts in Australia by simulating asset returns and liability values for discrete time periods and for a wide variety of models. The form of the constraints on the nature of the assets, on transactions, and on desired outcomes suggests a linear program to solve for the initial asset mix, in the simplest case. More complex analyses allow dynamic strategies to be found. Particular advantages of this approach are the ability to allow for major holdings of option contracts as assets, and to model aspects of managers' views of assets and liabilities that are hard to capture in a formula.

BORCH, K. "Insurance and the Theory of Asset Prices". Transactions of the International Congress of Actuaries (1980).

The paper gives an outline of the Asset Price Model. The author gives some examples of how this model can be applied in insurance and discusses some of the shortcomings of the model. He also presents an alternate model based on exponential utility functions. This model leads to loadings proportional to variance and to cumulants of higher order.

BORCH, K. "A Theory of Insurance Premiums". The Geneva Papers on Risk and Insurance No. 10 (July, 1985) 192-208.

The author presents a model of an insurance market and shows that a full generalization of CAPM is fairly simple. He also gives some examples and indicates how the model can be applied in practice. He claims that the "actuarial theory of risk" has lost considerable contact with economic reality.

BUTSIC, R.P. "Risk and Return for Property-Casualty Insurers". Total Return Due a Property-Casualty Insurance Company Discussion Paper Program, Casualty Actuarial Society, 1979, 52-95.

A study of the relationships between risk and return for property-casualty insurers, using concepts of the theory of financial economics.

CUMMINS, J.D., HARRINGTON, S. "Property-Liability Insurance Rate Regulation: Estimation of Underwriting Betas Using Quarterly Profit Data". Journal of Risk and Insurance 52 (1985) 16-43.

The underwriting beta is an important parameter in the application of financial theory to property-liability insurance pricing and rate regulation. This paper presents the results of using quarterly profit data to estimate underwriting betas for 14 property-liability insurers. Sensitivity of the estimates to alternative model specifications, market return series, and estimation periods is examined. The results imply that underwriting betas may have been subject to signficant instability during the 1970's. This finding suggests extreme caution if underwriting betas are to be used to establish fair profit margins in rate regulations. Possible reasons for instability in the estimated underwriting betas are discussed.

CUMMINS, J.D. "Risk Based Premiums for Insurance Guaranty Funds". International Conference on Insurance Solvency I, 1986.

This article develops premium equations for 3 cases:

(1) an ongoing insurer with stochastic assets and liabilities, but no additional sources of risk,

(2) an insurer with stochastic assets and liabilities and randomly occuring, lognormally distributed jumps in liabilities (catastrophes),

(3) a policy cohort, where the insurer's liability is gradually reduced as claims are paid.

These models provide a link between capital market theory and traditional actuarial ruin models.

CUMMINS, J.D., HARRINGTON, S.E. "The Relationship Between Risk and Return: Evidence for Property – Liability Insurance Stocks". Journal of Risk and Insurance 55 (1988) 15-31.

This paper tests the relationship between property-liability insurer stock returns and systematic risk, unsystematic risk, and co-skewness during the period 1970-83. The study is motivated by the use of CAPM and other financial models in insurance rate regulation. Insurance stock return patterns are consistent with CAPM during the period 1980-83 but inconsistent with the CAPM during earlier periods. Unsystematic risk is significantly related to returns in some of the equations, contrary to the predictions of the CAPM. The results imply that determining the fair rate of return solely on the basis of the CAPM may lead to incorrect results.

CUMMINS, J.D., DANZON, P.M. "Price Shocks and Capital Flows in Liability Insurance". International Conference on Insurance Solvency III, 1991

The authors use an option model of the firm to analyze the firm's response to a retroactive change in expected losses on prior policies that depletes capital, increases leverage and thereby disturbs the firm's target capital structure. If the target capital structure is to be restored, this must occur primarily through retained earnings, which requires that prices rise temporarily above long-run equilibrium levels. Price increases are feasible if firm-level demand is imperfectly elastic in the short run, because of information costs facing new entrants and costs to policyholders of switching. New equity will not flow in as long as the adequacy of reserves on prior years remains uncertain.

Empirical analysis, using firm-level data for the period 1980-1988, is generally consistent with the theoretical predictions. Safer firms tend to command higher prices in long-run equilibrium, but temporary losses of capital from normal long-run levels are associated with price increases. The addition of external capital is associated with higher prices, which is consistent with the "pecking order" theory, that external capital is more costly to the firm. Loss reserve adjustment on prior years is also associated with price increases, as required if a target capital structure is to be restored through retained earnings.

Issues of new capital are positively associated with shocks that leave capital below its long run equilibrium level, and with increases in premium rates and premium volume. These finding are also consistent with the target capital structure hypothesis.

CUMMINS, J.D. "Statistical and Financial Models of Insurance Pricing and the Insurance Firm". Journal of Risk and Insurance 58 (1991) 261-302

The author tries to reconcile the actuarial and the financial models of insurance, beginning with the idea of insurance pricing. He gives a brief background of statistical models of insurance, based on risk theory; then he gives a brief background to financial models of insurance, based on CAPM. Then he lists five areas where the integration of statistical and financial models would be valuable:

(1) the development of asset/liability management models that take into account more sophisticated models of the reserve run-off,

(2) financial models of reinsurance using option pricing theory, taking into account the fact that insurance claims are non-traded assets, and using probability distributions other than the lognormal,

(3) development of multiperiod option pricing models for long-tail insurance contracts, instead of using a funds generating or "k" factors approach to model the claims runoff process,

(4) adaptation of pricing and asset/liability management models to incorporate stochastic interest rates,

(5) endogenization of surplus.

DOHERTY, N. "On the Capital Structure of Insurance Firms". International Conference on *Insurance Solvency I*, 1986.

The author examines the capital structure of property-liability stock insurers. First, it is assumed that customers are unable to monitor the financial condition of the firm. Next, he examines the capital structure with financial monitoring showing the effect of product demand elasticities and cost functions. When time inconsistent incentives are considered, a zero surplus corner solution is found to be optimal. The zero surplus capital structure leaves an open question on the existence of an insurance market. However, it is then shown that existing regulations may promote constrained interior optimal solutions thereby providing an explanation for the presence of insurance carriers. Finally, the model predicts that the distribution of capital structures chosen by firms will be clustered within the constraint. Cross-section evidence is compatible with this prediction.

DOHERTY, N.A., KANG, H.B. "Interest Rates and Insurance Price Cycles". Journal of Banking and Finance 12 (1988) 199-214.

Property-liability insurance prices and profit appear to move in a six year cycle. Many industry analysts claim that the insurance market is inherently unstable and prices fail to converge on clearing levels. The authors have a different explanation. They identify spot equilibrium prices using CAPM. But informational, regulatory, and contractual lags preclude instantaneous adjustment. So they model the temporal movement of prices using a partial adjustment model in which actors form rational expectations. The actual movement of insurance prices does seem to track closely those estimated by the partial adjustment model. The cycle may be better viewed as a series of converging responses to changing spot prices.

FAIRLEY, W.B. "Investment Income and Profit Margins in Property-Liability Insurance: Theory and Empirical Results". Bell Journal of Economics 10 (1979) 192-210.

Capital market equilibrium rates of return on equity for property-liability insurers and underwriting profit margins by line that are consistent with these are derived by using the capital asset pricing model and measurements of cash flows by line. The profit solutions depend on the cash flows and systematic risks of the lines and on the yield of risk-free securities, but not on company investment portfolios. Recent historical profit margins by line are shown to be much closer to the solutions derived than to the traditional profit margin factors routinely included in rate filings in almost every state.

FELDBLUM, SHOLOM "Risk Loads for Insurers" Proceedings of the Casualty Actuarial Society, 77 (1990), 160-195.

Traditional methods of selecting risk loads are based on some of i) higher moments of the loss distribution ii) utility theory iii) the probability of ruin and iv) reinsurance costs. The author claims these methods are theoretically unsound. He goes on to suggest the proper approach is through modern portfolio theory, in particular application of the Capital Asset Pricing Model.

FERRARI, J. "A Theoretical Portfolio Selection Approach for Insuring Property and Liability Lines". Proceedings of the Casualty Actuarial Society, (1990), 33-69.

Portfolio selection theory, as developed by Markowitz for selection of investments, is applied to suggest the theoretical, optimal diversification of lines of insurance written by property and liability insurance companies.

FIELDS, J.A., VENEZIAN, E.C. "Interest Rates and Profit Cycles: A Disaggregated Approach". Journal of Risk and Insurance 56 (1989) 312-319

The authors redefine the nature of the returns that are studied and conclude that disaggregated models with interest rate terms perform better than simple autoregressive models in explaining the behaviour of profits.

GARVEN, J.R. "On the Application of Finance Theory to the Insurance Firm". International Conference on Insurance Solvency I, 1986.

The author applies financial theory to the question of insurance solvency. He analyzes optimal capital decisions in the context of an unregulated insurance market. This analysis suggests that, even in an unregulated market, insurers would voluntarily limit their premium-capital ratios in an effort to economize on contracting costs. Furthermore, mutual insurers are likely (all other things being equal) to be less highly levered than insurers organized as stock corporations.

HAMMOND, J.D., MELANDER, E.R., SHILLING, N. "Risk, Return, and the Capital Market". Journal of Financial and Quantitative Analysis 11 (1976) 115-131

The authors studied the investment results of a sample of property-liability insurers. The analysis shows that insurer investment performance parallels that of other investors: greater returns are associated with greater variability. However, with the acquisition of higher levels of investment, risk insurers generally reduce the level of underwriting risk which is undertaken. Thus, management attempts to keep ruin probabilities within some undefinable but clearly present limits. In the process of trading off between investment and underwriting risk, a higher rate of return to net worth is sacrificed.

HAMMOND, J.D., SHILLING, N. "Some Relationships of Portfolio Theory to the Regulation of Insurer Solidity". Journal of Risk and Insurance 45 (1978) 377-400

Underwriting risk and return data for a sample of both established and known high-risk insurers are examined in relation to actual and estimated maximum ratios of premium to surplus. Risks of ruin associated with these ratios are part of the analysis. Efficient underwriting frontiers for the industry and two sample insurers are presented. Limitations of the theory's application are noted. Its principal contributions to solidity regulation are to generate underwriting risk and return data in an integrated frame of reference and to generate information to supplement regulatory judgments about insurer solidity.

HAUGEN, R.A., KRONCKE, C.O. "Optimizing the Structure of Capital Claims and Assets of a Stock Insurance Company". Journal of Risk and Insurance 37 (1970) 41-48

This paper presents a technique to aid management in optimizing the portfolios of claims and investments and the degree of leverage in the capital structure. To invest capital optimally, management must measure capital costs and investment return accurately and be able to relate the risk-return characteristics of the array of capital claims to each other as well as to its portfolio of assets.

HILL, R.D., MODIGLIANI, F. "The Massachusetts Model of Profit Regulation in Non-life Insurance: An Appraisal and Extensions". Fair Rate of Return in Property Liability Insurance (ed. Cummins, Harrington) 1987, Kluwer-Nijhoff, Boston

This is an appraisal of the Fairly model of insurance pricing. There are two principal advantages of the Fairley model:

(1) it relies on current yields available to investors,

(2) it is the only one that provides a quantifiable measure of underwriting risk. However, the model is based on the CAPM, which has been faulted on a number of grounds. However, the fact remains that the CAPM is attractive because of its potential testability.

HILL, R.D. "Profit Regulation in Property-Liability Insurance". Bell Journal of Economics 10 (1979) 172-191

This article uses the capital asset pricing model to determine the competitive insurance premium and profit rate. Fair profit rates for real lines of insurance are then calculated and compared with actual profit rates. The comparison suggests that rule-of-thumb profit rates used in regulation lie above the level that would occur in a competitive insurance market.

41

HOYT, R.E., TRIESCHMANN, J.S. "Risk/Return Relationships for Life-Health, Property-Liability and Diversified Insurers". Journal of Risk and Insurance 58 (1991) 322-330

The authors do a risk/return analysis using both mean-variance and CAPM approaches. Both accounting and market data are used to measure profitability. The results show that, for the years 1973-1987, investment in individual life-health and property-liability insurers was better than investment in diversified insurers. Evidence also indicates that accounting measures of profitability may be poor proxies for market performance.

KAHANE, Y. "Determination of the Product Mix and the Business Policy of an Insurance Company - A Portfolio Approach". Management Science 23 (1977) 1060-1069

The author sets out a model which simultaneously determines the optimal composition of the insurance and investment portfolios of an insurance company using Sharpe's Single-Index Technique. This method takes into account both risks and rates of return to determine the best mix of product lines for a firm to offer.

KAHANE, Y., NYE, D. "A Portfolio Approach to the Property-Liability Insurance Industry". Journal of Risk and Insurance 42 (1975) 579-598

This paper contains an analysis of a portfolio model which simultaneously optimizes the investment and insurance portfolios of the property-liability insurance industry. The mathematical formulation is an extension of earlier approaches in that it permits the direct development of the envelope efficiency frontier for all levels of insurance coverage. Using data on nineteen insurance lines and two types of assets for the period 1956-1971, efficient portfolios for both constrained and unconstrained solutions are obtained. In each case, some insurance lines tend to be consistently excluded from the optimal portfolios because of their risk-return characteristics. The implications of this effect on the availability of insurance and ratemaking are discussed. Finally, in contrast to accepted practice and theory it is found that the investment policy of the firm need not necessarily become more conservative as the insurance portfolio becomes more risky.

KAHANE, Y., TAPIERO, C.S., JACQUES, L. "Concepts and Trends in the Study of Insurers' Solvency". International Conference on Insurance Solvency I, 1986

This paper emphasizes the micro-economic and financial aspects of insurance insolvency. The classical approach to ruin is reviewed to provide a continuous-state stochastic approach to valuations of the asset-liability paradigm. Solvency is analyzed in analogy to the financial leverge problem, as well as being a problem of information exchange and incentives in a "game".

KROUSE, C.G. "Portfolio Balancing Corporate Assets and Liabilities with Special Application to Insurance Management". Journal of Financial and Quantitative Analysis 5 (1970) 77-105

This paper considers the simultaneous selection of investments, underwriting lines, and capital financing to form efficient mean-variance corporate portfolios. The analysis is directed toward development of decision rules for use in structuring the firm's business in terms of its balance sheet. The intent is to specify optimal target levels for balance sheet accounts consistent with broad corporate goals, especially in view of the various interrelationships among these "separate" accounts and, consequently, without the suboptimization inherent when considering the properties of each in isolation. The model for unifying these principal, and traditionally disparate, insurance management activities involves only an extension of conventional mean-variance portfolio techniques to include proper specification of:

 (1) conservation equations balancing the firm's sources and uses of funds,

 (2) constraints setting legal, market, and institutional restrictions on these sources and uses.

LAUNIE, J.J. "The Cost of Capital of Insurance Companies". Journal of Risk and Insurance 38 (1971) 263-268

This article shows that the accounting data contained in an insurance company balance sheet can be construed in a conventional cost of capital framework. The funds which are generated through the medium of the insurance operation such as the loss reserve and the unearned premium reserve in a property-liability company are considered as "quasi-debt". The loss on operations is one portion of their imputed cost. The constraints which state insurance regulations place upon the portfolio of an insurer represent another element of imputed cost. While estimation of the cost of equity capital of an insurance enterprise differs little from its industrial counterpart, the imputed cost of "quasi-debt" is difficult to quantify.

LEE, C.F., FORBES, S.W. "Dividend Policy, Equity Value, and Cost of Capital Estimates for the Property and Liability Insurance Industry". Journal of Risk and Insurance 47 (1980) 205-222

Based upon the corporate finance theory and concept, possible impacts of dividend policy on the market value of equity for the property and liability insurance industry are theoretically and empirically investigated. The finding is that some effects of dividend policy on the market value of equity exist in the property and liability insurance industry. In addition, alternative methods for estimating cost of capital also are empirically applied to the property and liability insurance industry.

McCABE, G.M., WITT, R.C. "Insurer Optimizing Behaviour and Capital Market Equilibrium". Journal of Risk and Insurance 44 (1977) 447-467

This paper develops a financial model of a non-life insurer selling in a monopolistically competitive market. Optimal values of pricing and claims settlement policy are found simultaneously when profits are maximized. The necessary conditions for equilibrium and stability in the model and the sensitivity of the optimal decision variables to changes in parameters of the model are also analyzed. The implications of the model are assessed for capital market equilibrium and for the equilibrium market price per share of insurer's stock.

MYERS, S.C., COHN, R.A. "A Discounted Cash Flow Approach to Property-Liability Insurance Regulation". Fair Rate of Return in Property Liability Insurance (ed. Cummins, Harrington) 1987, Kluwer-Nijhoff, Boston

This paper discusses the difficulties in calculating the discount rate from the CAPM, which requires that the beta of the insurance policy be measured. Measuring the betas can be extremely difficult, for several reasons:

   (1)   portfolio composition varies widely from company to company and over time,

   (2)   random error in measuring beta for common stocks,

   (3)   insurance companies which have investments outside the insurance industry,

   (4)   the beta values vary widely for different lines of insurance.

QUIRIN, G.D., WATERS, W.R. "Market Efficiency and the Cost of Capital: The Strange Case of Fire and Casualty Insurance Companies". Journal of Finance 30 (1975) 427-450

The authors studied a sample of 25 Canadian insurance companies from 1961-1971. The results show that these companies earned rates of return in excess of that predicted by the Capital Asset Pricing Model. The authors' preferred explanation is that "risk of ruin" is a third argument (in addition to expected rate of return and variance) in the utility functions of company management. The authors believe that the rationale for this lies in the fact that insurance companies are subject to regulatory constraints which may render them technically insolvent even though policyholders' surplus has not been fully exhausted.

REID, D.H. "Solvency: The Expression of the Relationship Between Capital and Insurance Markets". Transactions of the International Congress of Actuaries (1984)

This paper is concerned essentially with non-life insurance business and the following questions:

(1)   how do the requirements of the stock market translate into objectives at line or underwriting level in the insurance market?

(2)   is it possible to measure the extent to which returns available in the insurance market satisfy, in principle, the trading needs of a quoted insurance company?

By studying a model of U.K. insurance business, it is found that the insurance aspects relevant to reasonable corporate objectives are characterized by the growth/profitability relationship available in the insurance market, and that this relationship is sufficient, under the assumption of the model, to determine progress toward certain specified objectives.

SCOTT, J.H. "A Theory of Optimal Capital Structure". Bell Journal of Economics 7 (1976) 33-54

This paper presents a multiperiod model of firm valuation derived under the assumptions that bankruptcy is possible and that secondary markets for assets are imperfect. Given the assumption that the probability of bankruptcy is zero, the model is formally identical to that proposed by Modigliani and Miller. Under plausible conditions the model implies a unique optimal capital structure. Comparative statics analysis is used to obtain a number of testable hypotheses which specify the parameters on which optimal financial policy depends. Implications for the debt policy of the regulated firm are also considered.

STAKING, K.B., BABBEL, D.F. "Interest Rate Sensitivity and the Value of Surplus in the Property-Liability Insurance Industry". International Conference on Insurance Solvency III, 1991

The relationship between leverage, interest rate risk and firm value is investigated in the property-liability insurance industry. The market reward for financial structure measured using Tobins q, the ratio of market value to replacement value of surplus is found to be related to a firm's choice of financial structure. Firm value at first increases with leverage but then declines at higher levels of leverage. Interest rate risk has the opposite effect. Insurer value declines with interest rate risk, but there is some evidence that high levels of interest rate risk are associated with increased value. These results support theories on leverage and interest rate risk for financial intermediaries.

45

TAPIERO, C.S., ZUCKERMAN, D., KAHANE, Y. "Optimal Investment-Dividends Policy of an Insurance Firm under Regulation". Scandinavian Actuarial Journal (1983) 65-76

An insurance decision model including intervention by a regulating agency is defined. The insurance firm's problem is to establish an investment policy as well as a dividend strategy. Regulation is exercised by a minimal barrier policy for cash holding and penalties for violating this barrier. The joint Insurance Firm-Regulating Agency problem is discussed by using concepts from Stackleberg strategies in game theory. As in the classical model of collective risk theory it is assumed that premium payments are received deterministically from policyholders at a constant rate, while the claim process is compound Poisson. A diffusion approximation is used in order to obtain tractable results for a general claim size distribution.

TURNER, A.L. "Insurance in an Equilibrium Asset Pricing Model". Fair Rate of Return in Property-Liability Insurance (ed. Cummins, Harrington) 1987, Kluwer-Nijhoff, Boston

This paper develops a theory of insurance markets in response to real-asset risks. Once insurance is added to the general economy, the value of any asset is the present value of the certainty-equivalent cash flows on the asset. However, this does not mean that the price mechanism is independent of individual risks. In fact, for very generally defined individual risks (i.e. not necessarily independent), the individual risks in the economy are involved in pricing every asset. For the special case of independent individual risks, the main previous results are preserved.

VENEZIAN, E.C. "Insurer Capital Needs Under Parameter Uncertainty". Journal of Risk and Insurance 50 (1983) 19-32

With uncertainty in the parameters, the safety capital must be defined in terms of a desire to meet a solvency criterion with a given reliability. Using such a definition, the effect of pooling risks on the financial efficiency depends on the characteristics of the uncertainty. If the variance in the estimates declines as the inverse of the number of policies on which information is available, the elasticity of capital per risk with respect to risks pooled is basically the same as with known parameters. If the uncertainty is independent of the number of risks in the data base, the elasticity declines with the size of the insurer. The elasticity of capital per risk with respect to the number of risks on which information is available declines as the ratio of relevant data on past losses to insured risk increases. If the variance in the estimates is independent of the data on the losses, pooling loss information has no effect on financial efficiency.

VENEZIAN, E.C. "Effect of Serially Autocorrelated Profit Margins on the Solvency of Insurers". International Conference on Insurance Solvency II, 1988

The determination of profit margins using modern financial methods has been discussed by a number of authors. The analysis has always been based on the requirements of competitive equilibrium in financial markets. The work has never continued to establish other essential elements, specifically the implications for solvency of the calculated rates. This paper assesses the impact of equilibrium rates on the solvency of insurers. Two measures of solvency are used, the probability of remaining solvent, and the present value of the future net worth discounted at the rate appropriate under the Capital Asset Pricing Model. The second measure, assessed when the insurer pays no dividends, is termed the capacity ratio. The paper explores these margins of solvency as a function of the serial autocorrelation of the profit margins. Autocorrelation has a profound effect on solvency. Strong autocorrelation, such as that found for industry-wide margins, may improve the probability of remaining solvent, but reduces the capacity ratio.

von EIJE, J.H. "The Value of Ceded Reinsurance". International Conference on Insurance Solvency II, 1988

While actuaries consider ceded reinsurance to be valuable because of its positive impact on solvency, financial economists frequently contest the value of the reinsurance to the shareholders of a primary insurance company. This paper presents an integration of these views. It is shown that, under traditional premium calculation principles, reinsurance cessions may improve stockholders' wealth if:

1.   improvements in solvency increase the expected future cash flows,
2.   systematic risk is reduced.

Actuarial concepts like "the normal power approximation" and "structure variation" are used. The economic theory is illustrated with results of a reinsurance optimizing routine.

von EIJE, J.H. "Solvency Margins and the Optimal Amount of Equity in Insurance Companies". International Conference on Insurance Solvency III, 1991

In 1985, Borch used the value of a company to its owners as a criterion on offering insurance cover. He showed that the additional equity invested will increase the value of the company. The maximum value will be found if company value equals the amount of equity invested in the company. Both value and equity are, however, measured in monetary terms. The investment of an additional unit of equity is therefore only considered if it creates at least one additional unit of company value. Maximizing the value of the company will - within a certain range - however result into negative monetary returns on equity invested. Therefore, instead of maximizing the value of the company, owners will be induced to maximize the amount of goodwill, which is the difference between company value and equity invested. According to Borch, the government would not need to set solvency margins, because the strive for company value would reduce the probability of ruin. If, however, shareholders maximize goodwill, solvency regulations may still be needed in order to protect the clients. The author first summarizes the ideas of Borch. Then he discusses the optimizing criterion used and tries to show why rational investors will maximize company goodwill and not company value. The results of some calculations for given distributions are then presented and it is shown that government regulations may still be necessary.

B - IV

Papers on Loss Reserving

ARATA, D.A. "Loss Reserving for Solvency". Proceedings of the Casualty Actuarial Society 70 (1983) 1-21.

The author discusses the role of loss-reserving in protecting a casualty insurer's solvency, specifically the fact that loss reserving plays a different role in different sized companies. He states that most small firms do not choose loss reserving policies appropriate to their specific type of capitalization. This paper gives an example of how a small company can improve its capital structure by appropriate loss reserving policies.

ASHE, F. "An Essay at Measuring the Variance of Estimates of Outstanding Claim Payments". Astin Bulletin 16, S (1986), 99-113

This paper examines the variance of statistical elements of outstanding claim payments for long-tailed general insurance portfolios. The variance's three components are discussed. As there is no accepted technique for measuring this variance, three methods are investigated empirically for its measurement – a parametric method, the jackknife method, and the bootstrap method. No method stands out as superior to the others and it is recommended that all three be evaluated and used to gauge the possible errors in the estimation of outstanding claims.

BENJAMIN, S. "Solvency and Profitability in Insurance". Transactions of the International Congress of Actuaries (1980).

This paper gives reasons why the actuarial profession should beware of discussing the financial position of an insurance company (a) within the conceptual framework of GAAP as used for life insurance companies in the U.S.A., and (b) within the conceptual framework of conventional accounting throughout the world for non-life companies. The paper argues that the conventional split between (i) technical provisions (reserves) and (ii) the free assets forming the solvency margin is false. Hence the practice whereby (i) is estimated without regard to the arbitrary level of (ii) which is set by the control authorities, should be unacceptable to the actuarial profession.

The paper argues that the traditional actuarial approach to cautious reserves in life insurance without arbitrary external solvency margins gives an acceptable conceptual framework for both life and non-life insurance accounts, and is consistent with good supervision in a free competitive market. A simple method of assessing the strength of an insurance company, based on past loss-ratios is suggested in an Appendix.

BUTSIC, R.P., "Determining the Proper Interest Rate for Loss Reserve Discounting: An Economic Approach". Evaluating Insurance Company Liabilities Discussion Paper Program, Casualty Actuarial Society, 1988, 147-188.

The discount rate for loss reserves should be the riskless yield rate (for government bonds) less risk adjustment. The adjustment reflects the degree of risk present in the outstanding reserve. Analysis of industry data over a 15-year period, using an industry pricing model, leads to estimates for the risk adjustment.

BUTIC, R.P. "The Effect of Inflation on Losses and Premiums for Property-Liability Insurers", Inflation Implications for Property-Casualty Insurance. Discussion Paper Program, Casualty Actuarial Society, 1981, 58-109.

A thorough discussion of the effect of inflation on losses, loss reserves, and discounting. The effects of inflation are mitigated by taking investment income into account. More stable estimates of true liabilities may be obtained if loss reserves are discounted.

BYRNES, J.F. "A Survey of the Relationship Between Claims Reserves and Solvency Margins". Insurance Mathematics and Economics 5 (1986) 3-29.

The extent to which the valuation of claims reserves for regulatory purposes is influenced by the existence of solvency margins is necessarily an administrative and legal problem rather than actuarial. However, actuarial concerns are considered and this paper compares various approaches to the solvency margin that were current when the Australian supervising legislation was developed. If any of them were actually consulted then it would appear that the Australian solvency margin is not to provide a buffer on claims reserves, which must be provided separately. Moreover it was a relatively stringent margin. The paper further explains how it came to be further tightened.

DAYKIN, C. "The Development of Concepts of Adequacy and Solvency in Non-life Insurance in the EEC". Transactions of the International Congress of Actuaries (1984).

This paper traces the development of requirements for minimum solvency margins in non-life insurance in the EEC, starting with work caused out under the auspices of OECD by Professor Campagne. It considers the relationship between the explicit solvency margin and what is understood to be covered by the technical reserves, the rationale for an explicit solvency margin and the origins of the particular level of solvency margin chosen. The paper concludes with some thoughts on a rational framework for defining technical reserves and an appropriate corresponding solvency requirement.

51

DE JONG, P., ZEHNWIRTH, B. "Claims Reserving, State-Space Models and the Kalman Filter". Journal of the Institute of Actuaries 110 (1982) 157-182

This paper describes a consistent and justifiable means of establishing adequate claims provisions in general insurance. The author discusses the claims reserving problem as well as the general state-space framework and Kalman filter. A suitable state space model is then developed for the claims reserving context. This approach emphasizes the forecasting nature of the claims reserving problem and takes advantage of the fact that the Kalman filter is a "real-time" device: every new observation leads to a simple update of existing estimates without needing to keep track of all previous information. The method is illustrated using a simple example taken from the experience of a U.K. general insurer from 1970-1974. Finally, the issue of forecasting future payments is described.

FINSINGER, J., PAULY, M. "Reserve Levels and Reserve Requirements for Profit Maximizing Insurance Firms". Risk and Capital (ed. Bamberg, Spremann) 1983, Springer-Verlag, Heidelberg

The authors study the conditions that determine the level of reserves that a company would hold in the absence of regulation. In the case where there is no covariance of firm risk with market return, agency costs are small, and fixed costs moderate, then regulation is probably unnecessary. In other cases, however, there is a social gain to be had from regulation.

GRACE, E.V. "Property-Liability Insurer Reserve Errors: A Theoretical and Empirical Analysis". Journal of Risk and Insurance 57 (1990) 28-46

This article formulates hypotheses concerning property-liability insurer use of reserving errors from 1966 to 1979. A general theory is developed in which an insurer maximizes discounted cash flow subject to estimation errors and income smoothing constraints. Empirical tests suggest that the theory appears to be consistent with insurer behaviour. Prior to 1972, reserving practices aided in reduction of tax bills subject to uncertain future claims costs. From 1972 to 1979, the causes of reserve errors appear to have altered somewhat. Reserve errors in the 1970's are related to taxable income and smoothing, as well as inflation rate changes.

GREELY, C., LEFF, H.B. "Reserves and Solvency in a Fluctuating Interest Rate Environment" Transactions of the International Congress of Actuaries (1984)

The paper reviews the evolution in laws and regulation that occurred in the U.S. in the 1970's and early 1980's. The authors stress the need for new approaches to the determination of reserve levels. It is no longer sufficient for the actuary to consider only the liabilities of the company. Instead, account must be taken of outside economic and other forces that give rise to present and future market value losses.

Reserves". Proceedings of the Casualty Actuarial Society, 76 (1989), 77-110.

The elements of collective risk theory are introduced with references to the recent literature. Application is made to the distribution of IBNR reserves. Higher moments of this distribution give an indication of the variability in the reserves.

PANJER, H.H., BROWN, R.L. "An Analysis of Loss Reserves in Canada". Institute of Insurance and Pension Research, Report #90-07, University of Waterloo, 1990.

This paper investigates the accuracy of loss reserves. Estimates made from 1975-1983 by Canadian property and casualty insurers were compared with results five years later. The variation of results is analyzed based on: size of company, domestic versus foreign companies, direct insurers versus reinsurers, year and company. The ultimate purpose is to provide an estimate of the amount of variability which cannot be explained by the listed factors. The resulting amount of variability gives an indication of the amount required for a provision for adverse deviation (PAD).

The authors discovered significant effects that have influenced the direction of the excess/deficiency of the loss reserves in the past. These effects were extracted and left a residual variation of about 35% of the original variation. This residual variation represents the degree of inherent instability of reserves of an individual company under the assumption that reserves are unbiased estimates of outstanding claims. The analysis showed that about half of the total variation was due to the tendency of individual companies to consistently under-reserve or consistenly over-reserve.

PENTIKAINEN, T., RANTALA, J. "Run-off Risk as a Part of Claims Fluctuation", Astin Bulletin 16 (1986) 113-147

The purpose of this paper is to discuss how the run-off risk could be incorporated into the standard risk theory model as a separate entry, and to find some evaluation of the order of magnitude of the extra fluctuation so rendered. At this stage of the research, the impact of parametric estimation is excluded from consideration. Therefore, the results and numerical examples do not describe the total uncertainty of claims or reserves. The authors study both the going-concern case, and the break-up case. They also use a simulation technique, which allows for more general assumptions about inflation.

PLYMEN, J. "Profitability and Reserve Strength of Non-life Insurers". Transactions of the International Congress of Actuaries (1976)

The author analyzed the accounts of the seven leading British world-wide insurance companies studying from their combined results, the average profitability of the fire and accident business, the strength of the free reserves, and the contribution to profits from interest on investments. The study shows that premiums gained 27 times between 1936-1973, but reserves only 11 times and dividends 8 times. Hence the growth of shareholders' dividends lagged behind the growth of premium income. The author uses a financial model to show how a company could operate successfully with lower reserve levels.

SOGN, E.T. "Aspects of Solvency Consideration in Non-life Insurance". Transactions of the International Congress of Actuaries (1984)

This paper gives some background for the solvency control project in Norway, initiated in 1982. Its working party was appointed with the task of setting rules for the technical reserves, and also asked what general capital requirements should be imposed upon non-life companies. Only the first task is treated in this paper. The author discusses different aspects to be covered in such a work and also outlines general principles for further development.

VAN SLYKE, O.E. "Regulatory Standards for Reserves". Financial Analysis of Insurance Companies Discussion Paper Program, Casualty Actuarial Society, 1987, 368-421

A reserving method is proposed which reflects the risk associated with possible eventual claim payments as well as with the expected value of those claim payments. The method involves consideration of a variety of possible future scenarios and an application of utility theory.

VENEZIAN, E.C. "Effect of Reserve Smoothing on Solvency and Financial Performance When Profit Margins are Serially Autocorrelated". International Conference on Insurance Solvency III, 1991

This paper uses simulation methods to determine the effect on solvency when management bases the relation between premiums and net worth on estimates of net worth that are derived from smoothed values of the reserves for unpaid losses. Two measures of solvency are used, the probability of remaining solvent and capacity ratio which is the present value of the future net worth discounted at the rate appropriate under the Capital Asset Pricing Model assuming the insurer pays no dividends. The extent of smoothing has a strong effect on solvency, especially at large values of the ratio of premiums to net worth. Except in extreme cases smoothing increases the probability of remaining solvent over long periods of time and also increases the expected value of the capacity ratio. At ratios of premiums to net worth of five or six the effect is strong enough that the natural selection of companies that smooth results would, over a century or so, lead to a market dominated by smoothers. At lower ratios the effect is perceptible but not strong enough to affect the market composition over the course of one century.

B - V

Papers on Statistical Methods

AMBROSE, J.M., SEWARD, J.A. "Best's Ratings , Financial Ratios and Prior Probabilities in Insolvency Prediction." Journal of Risk and Insurance 55 (1988) 229-244.

The authors used multivariate linear discriminant functions to compare the insolvency prediction abilities of Best's ratings, sets of financial ratios, and a two-stage prior probability approach. It was found that the performances of Best's ratings and financial ratios were statistically equivalent. The two-stage technique outperformed the others in identifying insolvent firms but misclassified a higher proportion of solvent firms. The paper concludes that Best's rating method is valid, but prediction capability could be improved with a two-stage approach. The prior probabilities from a Best's ratings analysis could be calculated from the population of all rated insurers.

ALTMAN, E.I. "Corporate Financial Distress – A Compute Guide to Predicting, Avoiding, and Dealing with Bankruptcy", John Wiley & Sons, New York, 1983

ALTMAN, E.I. The Success of Business Failure Prediction Models, Journal of Banking and Finance, No. 8, 1984, 171-198

ALTMAN, E.I. "The Prediction of Corporate Bankruptcy – A Discriminant Analysis", Garland Publishing 1988

ARTHUR D. LITTLE. "Studies on the Profitability, Industrial Structure, Finance and Solvency of the Property and Liability Insurance Industry". Publication #71948, 1970.

This paper, written by Irving Plotkin, Senior Economist at ADL, reviews, updates, and extends his original work on profitability. It discusses the criticisms of his study offered by various authors. It also discusses some of the legislative/regulatory history of his studies, and extends his work to cover the effect of premium - surplus ratios on profitability, investor risk, insolvency and capital attraction. The results of these investigations were used in the (then) recently completed New Jersey rate case.

BAR-NIV, R., HERSHBARGER, R.A. "Classifying Financial Distress in the Life Insurance Industry". International Conference on Insurance Solvency II, 1988

The scope of this paper is to review the financial operations of life insurance companies in order to detect variables which will be helpful in identifying potential insolvencies. Three multivariate analyses are used in this paper: Multidiscriminant Analysis (MDA), nonparametric analysis, and a logit analysis. The NAIC-IRIS tests the decomposition measures and other financial ratios are found to be accurate measures for classifying failures in a multivariate framework one and two years prior to insolvency. The analyses correctly classify between 82 and 91 percent of the life insurance companies one and two years prior to insolvency. Cross-sectional validation on 31 publicly traded life insurers indicates that these large insurers are relatively safe. All these life insurers are correctly classified as solvent companies. However, further analyses of these models and a prospective probability model indicate that more than one multivariate analysis may be required for measuring the probability of failure.

BECKMAN, R.W., TREMELLING, R.N. "The Relationship Between Net Premium Written and Policyholders' Surplus". Proceedings of the Casualty Actuarial Society 59 (1972) 203-220.

The authors make the following arguments based on the stock insurance industry premium-surplus ratio for the period 1928-1970:

(1) the stock market is the major factor affecting policyholders' surplus and the premium-surplus ratio.

(2) the premium-surplus ratio measures the leverage of an insurance company and so the stockholders should prefer a higher ratio, but from the policyholders' viewpoint, this ratio is an indication of the strength of the insurer and thus a lower ratio indicates a more heavily capitalized and "stronger" insurer.

(3) the net premium written – policyholders' surplus ratio is distorted because policyholders' surplus has been overstated.

BEENSTOCK, M., DICKINSON, G., KHAJURIA, S. "The Relationship Between Property-Liability Insurance Premiums and Income: An International Analysis". Journal of Risk and Insurance 55 (1988) 259-272

Annual cross-section data for 12 industrialized countries observed over 1970-1981 are pooled in an econometric investigation of the relationship between income and spending on property-liability insurance. A theoretical framework is specified for the supply and demand for insurance in which premiums depend on income and interest rates. The econometric results are used to measure the short and long run marginal propensities to insure across the 12 countries. The paper concludes with a cross-section analysis of 45 countries in 1982 in which the relationship between economic development and property-liability insurance premiums is investigated.

CUMMINS, J.D., NYE, D.J. "The Stochastic Characteristics of Property-Liability Insurance Company Underwriting Profits". Journal of Risk and Insurance 47 (1980) 61-77.

Research on property-liability insurance often depends on the assumptions that combined ratios are normally distributed and/or uncorrelated with yield rates on common stocks. This study examines 206 combined-ratio time series for nine major lines of insurance in order to guage the accuracy of these assumptions. The normality hypothesis is accepted for approximately one-half of the series, many are highly correlated with the industry-wide combined-ratio, and almost none are significantly correlated with equity yields. An important implication is that mean-variance models should not be used in insurance research without validating the normality assumption or determining the impact of departures from normality.

DAYKIN, C. "The Development of Concepts of Adequacy and Solvency in Non-life Insurance in the EEC". Transactions of the International Congress of Actuaries (1984).

This paper traces the development of requirements for minimum solvency margins in non-life insurance in the EEC, starting with work caused out under the auspices of OECD by Professor Campagne. It considers the relationship between the explicit solvency margin and what is understood to be covered by the technical reserves, the rationale for an explicit solvency margin and the origins of the particular level of solvency margin chosen. The paper concludes with some thoughts on a rational framework for defining technical reserves and an appropriate corresponding solvency requirement.

de WIT, G.W., KASTELIJN, W.M. "The Solvency Margin in Non-life Insurance Companies". Astin Bulletin 11 (1980) 136-144.

This paper reviews the O.E.C.D. calculations applying to the Netherlands for 1952-57, and discusses two ideas from O.E.C.D. report: expense ratio and claims ratio. In 1952-57, with probability of ruin = 0.003, the necessary solvency margin was 31%. In 1976-1978 with the same probability of ruin, the necessary solvency margin was 60% (again for Netherlands). The level of the solvency margin is determined not only by the claims and expense ratio, but more specifically, by the variance of these figures.

FORBES, S.W. "Capital Gains, Losses and Financial Results in the Non-Life Insurance Industry". Journal of Risk and Insurance 42 (1975) 625-638.

This paper studies the period 1956-72 to explore the impact of capital gains and losses upon the risk/return and solvency positions of stock and mutual non-life insurers. For most insurers, the risk/return ratio deteriorated when capital gains and losses were included in earnings. If risk dimension is ignored, most insurers appeared heavily dependent on capital gains for average earning improvements. Ample capital and/or surplus margins were available to enable most of the insurers to absorb substantially greater capital losses than those which had occurred. The main conclusion is that equity investments provided additional regulatory problems but did not on the average contribute to the efficiency of these firms.

GABUS, A., HAGEMANN, S. "Solvency Margin and its Effects on Competition". The Geneva Papers on Risk and Insurance No. 19 (April 1981) 3-84

This study has tried to identify disparities among companies classifiable, a priori, according to the following characteristics:

(1)   meeting the current solvency margin/financing future margin,

(2)   growth on a single national market/foreign markets,

(3)   long term/short term,

(4)   subjective/objective.

The following areas have been studied:

(1)   economic consequences of uniform calculation of the margin,

(2)   principle of supervision and the practice of the solvency certificate,

(3)   accounting for hidden reserves due to underestimation of assets or overestimation of liabilities,

(4)   financing the margin whether the disparities arise from differences in operating conditions, financing conditions, or general economic conditions.

The study is restricted to members of the EEC.

HARRINGTON, S.E., NELSON, J.M. "A Regression-Based Methodology for Solvency Surveillance in the Property-Liability Insurance Industry". Journal of Risk and Insurance 53 (1986) 583-605

This paper suggests a new method for assessing property-liability insurer financial strength. The procedure uses regression analysis to estimate the relationship between premium-surplus ratios and insurer characteristics including asset and product mix variables. Analysis of the regression residuals then identifies insurers with ratios that are substantially higher than those for insurers with similar characteristics. The method is illustrated by using data for solvent and insolvent insurers. Its ability to identify insurers that later became insolvent is compared to that of the NAIC Insurance Regulatory Information System.

LUDWIG, S.J., McAULEY, R.F. "A Nonparametric Approach to Evaluating Reinsurers' Relative Financial Strength". Proceedings of the Casualty Actuarial Society 75 (1988) 219-240

This article presents a model that uses properties of a ranking distribution. The Wilcoxon rank sum test is initially used to determine which financial ratios have historically discriminated between "strong" and "weak" companies. For those ratios that are selected as good discriminators, the test ranks are summed for each company. This statistic is then used as the measure of relative financial strength.

MUNCH, P., SMALLWOOD, D.E. "Solvency Regulation in the Property-Liability Insurance Industry: Empirical Evidence". Bell Journal of Economics 11 (1980) 261-279

This article reports empirical evidence concerning the effects of solvency regulation on the number of companies and frequency of insolvencies. Minimum capital requirements appear to reduce insolvencies by reducing the number of small, domestic firms. This supports the view of capital requirements as a differentially higher tax on small, new firms. Other forms of regulation have ambiguous effects or none. A comparison of the characteristics of insolvent and solvent firms supports the model of insolvency as the unlucky outcome of value-maximizing risk-taking.

PINCHES, G.E., TRIESCHMANN, J.S. "Efficiency of Alternative Models for Solvency Surveillance in the Insurance Industry". Journal of Risk and Insurance 41 (1974) 563-577

The authors examined the efficiency of alternative models for solvency surveillance of property-liability insurance firms employing financial ratios. The two models investigated are:

1. financial ratios individually or in groups on a univariate basis,

2. set of financial ratios in a multivariate context based on a multiple discriminant model.

It is shown that the second model does a better job of identifying firms with a high probability of distress.

PLOTKIN, I.H. "Rates of Return in the Property-Liability Insurance Industry: A Comparative Analysis". Journal of Risk and Insurance 36 (1969) 173-200

This paper reports on a comprehensive study of the profitability of the *P* and *L* insurance industry undertaken as part of a general investigation of insurance prices and investment income. From a socio-economic point of view it compares risk and returns on invested capital with numerous other financial and nonfinancial sectors of the American economy. In measuring return, all possible sources of income have been considered including unrealized capital gains as well as incomes attributable to the use of mixed cash/accrual accounting systems. The risk/return comparisons are based on a 60 industry, 16 year econometric study. The conclusions are based not on a sample, but on industry aggregates as well as on several measures of financial return. No evidence of excessive return was found. These theoretical conclusions are examined against and verified by current industry experience.

RAMLAU-HANSEN, H. "A Solvency Study in Non-Life Insurance Part I". Scandinavian Actuarial Journal (1988) 3-34

This paper describes a study of statistical analyses of policy and claims data of a portfolio of fire, windstorm, and glass liabilities of single family houses and dwellings. Claim frequencies and claim size distributions are estimated, and the results are used to derive moments of the annual claim amounts and to provide examples of solvency margin requirements for different classes of business.

RAMLAU-HANSEN, H. "A Solvency Study in Non-Life Insurance Part II". Scandinavian Actuarial Journal (1988) 35-59

This paper shows how the solvency margin depends on portfolio composition and volume, reinsurance, time horizon, probability of ruin, and the values of some of the basis parameters. The results show that 8-28% of premium income is necessary to cover the random fluctuations in claim costs. However, statutory requirements should be higher (25-43%) to provide reasonable protection against inadequate safety loadings.

ROSS, J.A., POUNTAIN, C.C. "Comparison of International General Insurance Underwriting Results and their Volatility". Transactions of the International Congress of Actuaries (1988)

This paper studies underwriting results in seven major international markets over the period 1975-1984. The reason for the study is that many companies try to mitigate the underwriting cycle by international diversification. The study shows that Japan, followed by Germany, was the most profitable market, with France being the least. Germany and France had the least variable markets while Australia, followed by the U.S.A., was the most variable. All markets were positively correlated, with Germany being the least so. The conclusion is that since international markets tend to move in the same direction, diversification can limit the worst effects of the cycle but not overcome it.

61

SALZMANN, R.E. "RLS Yardsticks to Identify Financial Weakness". Proceedings of the Casualty Actuarial Society 68 (1981) 172-194

This paper proposes a third method of identifying financially troubled insurers. (The first two are the NAIC IRIS ratios, and the AIA Index of Financial Strength). The author claims that there are seven areas of critical financial significance: reserve level, surplus level, liquidity, quality of assets, operating results, excessive growth and reinsurance protection. The RLS method places primary emphasis on reserve, liquidity, surplus levels. An insurer is exposed to insolvency hazards because of both insufficient surplus and insufficient financial flexibility levels. Therefore, this method uses one index to measure surplus position and another to measure liquidity position.

TREEN, W.R., THOMSON, A.K. "The Effects of Financial Factors on General Business Solvency". Transactions of the International Congress of Actuaries (1984)

This paper investigates the fluctuation in solvency caused by variations in claim inflation rates, interest rates, and asset values. The period under study was 1955-1980 in the U.K. Variations between the actual and expected claims liabilities were obtained and then related to solvency levels. The claims fund was also traced on the assumption that the investments were either Government securities, equities, or a mixture of asset types typical of the insurance business. The variation between expected and actual levels of this fund were seen to have a considerable effect on solvency levels.

TRIESCHMANN, J.S., PINCHES, G.E. "A Multivariate Model for Predicting Financially Distressed P.L. Insurers". Journal of Risk and Insurance 40 (1973) 327-338

A multiple discriminant analysis was used to classify firms into two groups (solvent or distress). Financial distress is defined as a firm that went into liquidation, receivership, conservatorship, or rehabilitation during the period of the study (1966-1971). The model was correctly able to classify forty nine out of fifty two firms in the study. One solvent firm was classified as being distress while two of the distress firms were classified as solvent. The six variables used in the study were:

    (1)   agents balance/total asset ratio,

    (2)   stocks cost/stocks market ratio,

    (3)   bonds cost/bonds market ratio,

    (4)   loss adjustment & underwriting/net premium ratio,

    (5)   combined ratio,

    (6)   premiums written direct/surplus ratio.

B - VI

Papers on Regulation

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BORCH, K. "Capital Markets and the Supervision of Insurance Companies". Journal of Risk and Insurance 41 (1974) 397-405.

An insurance policy offers adequate security only if the company holds large reserves. In a free economy such reserve capital can be obtained only from the market, and investors will be ready to provide the capital only if the insurance company can be expected to earn sufficient profits. The main task of the government supervisor is to make certain that the company's reserves remain adequate. This can be achieved only if the company is allowed to charge premiums which will lead to profits found satisfactory by investors. Good insurance at low prices may be impossible in an economy with free capital markets.

BORCH, K. "Is Regulation and Supervision of Insurance Companies Necessary?" Scandinavian Actuarial Journal (1981) 179-190.

The author states that if the company is primarily interested in making a quick profit, regulation may be necessary. On the other hand, if the management of the company takes a long-term view, no regulation should be necessary. He also shows that there are limits to what a government can achieve by regulation of private insurance companies which operate in a free economy.

CUMMINS, J.D., HARRINGTON, S. "Property-Liability Insurance Rate Regulation: Estimation of Underwriting Betas Using Quarterly Profit Data". Journal of Risk and Insurance 52 (1985) 16-43.

The underwriting beta is an important parameter in the application of financial theory to property-liability insurance pricing and rate regulation. This paper presents the results of using quarterly profit data to estimate underwriting betas for 14 property-liability insurers. Sensitivity of the estimates to alternative model specifications, market return series, and estimation periods is examined. The results imply that underwriting betas may have been subject to signficant instability during the 1970's. This finding suggests extreme caution if underwriting betas are to be used to establish fair profit margins in rate regulations. Possible reasons for instability in the estimated underwriting betas are discussed.

DOHERTY, N.A., GARVEN, J.R. "Price Regulation in Property Liability Insurance: A Contingent Claims Approach". Journal of Finance 41 (1986) 1031-1050.

A discrete-time option-pricing model is used to derive the "fair" rate of return for the property-liability insurance firm. The rationale for the use of this model is that the financial claims of shareholders, policyholders, and tax authorities can be modelled as European options written on the income generated by the insurers asset portfolio. This portfolio consists mostly of traded financial assets and is therefore relatively easy to value. By setting the value of the shareholders' option equal to the initial surplus, an implicit solution for the fair insurance price may be derived. Unlike previous insurance regulatory models, this approach addresses the ruin probability of the insurer as well as a nonlinear tax effect.

FINSINGER, J., PAULY, M. "Reserve Levels and Reserve Requirements for Profit Maximizing Insurance Firms". Risk and Capital (ed. Bamberg, Spremann) 1983, Springer-Verlag, Heidelberg

The authors study the conditions that determine the level of reserves that a company would hold in the absence of regulation. In the case where there is no covariance of firm risk with market return, agency costs are small, and fixed costs moderate, then regulation is probably unnecessary. In other cases, however, there is a social gain to be had from regulation.

HAMMOND, J.D., SHILLING, N. "Some Relationships of Portfolio Theory to the Regulation of Insurer Solidity". Journal of Risk and Insurance 45 (1978) 377-400

Underwriting risk and return data for a sample of both established and known high-risk insurers are examined in relation to actual and estimated maximum ratios of premium to surplus. Risks of ruin associated with these ratios are part of the analysis. Efficient underwriting frontiers for the industry and two sample insurers are presented. Limitations of the theory's application are noted. Its principal contributions to solidity regulation are to generate underwriting risk and return data in an integrated frame of reference and to generate information to supplement regulatory judgments about insurer solidity.

HAUGEN, R.A., KRONCKE, C.O. "Rate Regulation and the Cost of Capital in the Insurance Industry". Journal of Financial and Quantitative Analysis 6 (1971) 1283-1305

The authors discuss some of the effects of rate regulation in the property and casualty insurance industry. One consequence of the regulatory environment is that an optimal capital structure may clearly exist in this industry. If the rate of return to the insureds is generally deficient, it is expected that property and casualty stock companies would have an incentive to lever themselves to the maximum extent permissible by selling insurance. The classic monopoly of the economic literature finances its lucrative investment opportunities in a competitive capital market. The stock insurance company invests in that market, but the relative distribution of the return earned there may be less than equitable due to the process and standards of rate regulation.

HILL, R.D., MODIGLIANI, F. "The Massachusetts Model of Profit Regulation in Non-life Insurance: An Appraisal and Extensions". Fair Rate of Return in Property Liability Insurance (ed. Cummins, Harrington) 1987, Kluwer-Nijhoff, Boston

This is an appraisal of the Fairly model of insurance pricing. There are two principal advantages of the Fairley model:

(1) it relies on current yields available to investors,

(2) it is the only one that provides a quantifiable measure of underwriting risk. However, the model is based on the CAPM, which has been faulted on a number of grounds. However, the fact remains that the CAPM is attractive because of its potential testability.

HILL, R.D. "Profit Regulation in Property-Liability Insurance". Bell Journal of Economics 10 (1979) 172-191

This article uses the capital asset pricing model to determine the competitive insurance premium and profit rate. Fair profit rates for real lines of insurance are then calculated and compared with actual profit rates. The comparison suggests that rule-of-thumb profit rates used in regulation lie above the level that would occur in a competitive insurance market.

HUMPHRYS, R. "Standards and Solvency Requirements Under Canadian Insurance Legislation". Transactions of the International Congress of Actuaries (1984)

This paper discusses concepts of solvency and solvency standards under federal insurance legislation in Canada. Defects in the traditional balance sheet presentation are noted and suggestions made for improvement. In this light, Canadian capital and surplus margins are described. Special emphasis is placed on revised methods of reflecting both realized and unrealized capital gains in income statements. The importance of cash flow forecasting is stressed. Reference is made to recent reinsurance problems and the possible effect on balance sheet and other requirements.

KAHANE, Y. "Capital Adequacy and the Regulation of Financial Intermediaries". Journal of Banking and Finance 1 (1977) 207-218

This paper shows that constraining the portfolio composition of the intermediary, per se, cannot generally be regarded as an effective means for bounding the firm's probability of ruin; nor can the minimum capital requirement, per se. However, a combination of these regulatory practices may reach the desired effect.

KAHANE, Y. "Solidity, Leverage and the Regulation of Insurance Companies". The Geneva Papers on Risk and Insurance No. 14 (Dec. 1979) 3-19.

The purpose of this paper is to examine the effectiveness of regulatory policies and their adequacy for guaranteeing the soundness of the insurer's financial position. Three distinct models are examined. The first two models analyze the problem of ruin within a discrete time period through the application of the instruments of portfolio theory. The analysis is based on the proposition that capital requirement must be related to the overall performance of the insurance company. The overall performance is a function of both underwriting and investment incomes and their risks. For the third model the insurer is assumed to have only one activity, but the analysis is carried within a continuous time framework. It is argued that the desired regulatory effects can be achieved by introducing a set of penalties rather than through direct interference in the firms activities.

LAUNIE, J.J., PHILLIPS, G.M. "The Effect of Solvency Regulation in the Underwriting Cycle". International Conference on Insurance Solvency II (1988)

This paper focuses on the frequently utilized regulatory test for capacity which states that net premiums written should not be greater than three times policyholders' surplus. The difficulty with this solvency measure is that net premiums written is immediately affected by price changes. A simple example of the manner in which flows on this measure may exacerbate the underwriting cycle is given. This is followed by a formal model which measures the extent to which changes in net premium written reflects price changes rather than real changes in insurance exposure.

MYERS, S.C., COHN, R.A. "A Discounted Cash Flow Approach to Property-Liability Insurance Regulation". Fair Rate of Return in Property Liability Insurance (ed. Cummins, Harrington) 1987, Kluwer-Nijhoff, Boston

This paper discusses the difficulties in calculating the discount rate from the CAPM, which requires that the beta of the insurance policy be measured. Measuring the betas can be extremely difficult, for several reasons:

(1) portfolio composition varies widely from company to company and over time,

(2) random error in measuring beta for common stocks,

(3) insurance companies which have investments outside the insurance industry,

(4) the beta values vary widely for different lines of insurance.

NORBERG, R., SUNDT, B. "Draft of a System for Solvency Control in Non-Life Insurance".
Astin Bulletin 15 (1985) 149-169

An outline is given of a proposed system for solvency control in non-life insurance that has
recently been discussed within a Working Party appointed by the Norwegian supervisory author-
ities. According to this system the factual technical reserves must at any time be sufficient to
meet, with high probability, all future liabilities stipulated by insurance contracts that have either
expired or are currently in force. The system is applied to a provisional, simple model that has
been fitted to claims data assembled from Norwegian non-life companies. The numerical exam-
ples illustrate how the required reserve depends on the volume of the business, the portfolio mix,
and the reinsurance cover.

ROTH, R.J. "Measuring Solvency and the Adequacy of Casualty Loss and Expense Reserves
from the Point of View of Insurance Regulation". Transactions of the International Congress of
Actuaries (1984)

Loss reserves have been growing faster than written premiums and surplus, therefore increasing
the importance of proper reserving. However, due to the growth of reinsurance, loss reserving
has become even more difficult. Reforms are badly needed in the reporting of reinsurance tran-
sactions. Also, the solvency of many property-casualty insurers is being threatened by pro-
longed underwriting cycles.

SOGN, E.T. "Aspects of Solvency Consideration in Non-life Insurance". Transactions of the
International Congress of Actuaries (1984)

This paper gives some background for the solvency control project in Norway, initiated in 1982.
Its working party was appointed with the task of setting rules for the technical reserves, and also
asked what general capital requirements should be imposed upon non-life companies. Only the
first task is treated in this paper. The author discusses different aspects to be covered in such a
work and also outlines general principles for further development.

SUGARS, E.G. "A Risk Theoretic Prescription for Regulated Ratemaking". Journal of Risk and
Insurance" 39 (1972) 475-478

The author suggests a method, based on risk theory, for determining a fair rate of return in the
non-life insurance business. The paper contains the idea that rates should be loaded only enough
to allow the insurer a fair return on that part of policyholder surplus funds required to run a pru-
dent insurance business.

ZELTEN, R.A. "Solvency Surveillance: The Problem and a Solution". Journal of Risk and Insurance 39 (1972) 573-588

This study investigates insurance department examinations of insurance companies, and reveals the present examination system to be deficient in every respect. The author believes that annual independent audits should replace the mandatory, full scale, routine examinations of every insurer.

B - VII

Papers on Financial Reporting and Surplus Management

ALDIN, N. and JONES, B. "Measuring R.O.E. from a Financial Planning Perspective". Financial Analysis of Insurance Companies Discussion Paper Program, Casualty Actuarial Society, 1987, 3-23.

A method is proposed for assessing a financial product's performance in terms of return on equity. The equity backing the product is the appropriate level of risk surplus needed to account for the various risks inherent in the product. An application is made to a retrospectively rated workers' compensation product.

ANDERSON, J.J. "Alternative Methods of Accounting for Equity Investments in the Stock P-L Insurance Industry". Journal of Risk and Insurance 42 (1975) 263-275

The author discusses two accounting methods which were used in the property-liability insurance industry at the time, as well as two other methods which would reflect changes in unrealized appreciation on the equity security portfolio in the income statement. The article discusses the current status of the issue in the accounting community, describes the methods under consideration and evaluates them in terms of their intrinsic merit and their potential implications for the industry.

BENJAMIN, S. "Profit and Other Financial Concepts in Insurance". Journal of the Institute of Actuaries 103 (1976) 233-305.

The purpose of this paper is to introduce accountants and others working in insurance to the concepts and language of actuaries. Among other topics, the author discusses valuation of insurance companies. He criticizes the GAAP approach in the following manner: given two companies which are identical with respect to premium rates, volume of business, experience, etc., the only difference being that the first reserves on a stronger basis than the second, then the former is worth less to its shareholders in terms of rate of return. The actual reserving basis is ignored under GAAP and hence that real difference is ignored. The author also discusses the ideas of surplus analysis, and asset-liability matching.

BENJAMIN, S. "Solvency and Profitability in Insurance". Transactions of the International Congress of Actuaries (1980).

This paper gives reasons why the actuarial profession should beware of discussing the financial position of an insurance company (a) within the conceptual framework of GAAP as used for life insurance companies in the U.S.A., and (b) within the conceptual framework of conventional accounting throughout the world for non-life companies. The paper argues that the conventional split between (i) technical provisions (reserves) and (ii) the free assets forming the solvency margin is false. Hence the practice whereby (i) is estimated without regard to the arbitrary level of (ii) which is set by the control authorities, should be unacceptable to the actuarial profession.

The paper argues that the traditional actuarial approach to cautious reserves in life insurance without arbitrary external solvency margins gives an acceptable conceptual framework for both life and non-life insurance accounts, and is consistent with good supervision in a free competitive market. A simple method of assessing the strength of an insurance company, based on past loss-ratios is suggested in an Appendix.

BRUBAKER, R.E. "A Constrained Profit Maximization Model for a Multi-Line Property/Liability Company". Total Return Due a Property-Casualty Insurance Company Discussion Paper Program, Casualty Actuarial Society, 1979, 28-50.

The selection of product mix is presented as a constrained optimization problem: optimization of profits constrained by available capital needed to support various lines. The author applies a basic microeconomic model. It is assumed capital is allocated among lines so as to keep the probability of insolvency or impairment for each line within acceptable bounds.

BURROWS, R.P., FICKES, S.W. "Measuring the Financial Performance of Insurance Companies". Transactions of the International Congress of Actuaries (1988).

The authors state that methods such as statutory accounting, GAAP, and cash flow accounting are very poor indicators of the performance of insurance operations. A system currently in operation which effectively monitors insurance performance is the value-added reporting system. This system has the ability to measure financial results against targets and also provides meaningful information to management regarding the financial strength of the company. It has been implemented successfully by a number of insurance companies worldwide.

CHRISTENSEN, J.E. "Contingency Reserves in Surplus Allocation". Transactions of the International Congress of Actuaries (1984).

This paper suggests how contingency reserves might be used in surplus allocation. By splitting the portfolio according to underwriting year and allocating to each underwriting year a capital needed to ensure solvency (with a given probability), a distribution of the internal rate of return on that capital is established. The focus is on the function of the contingency reserve as a way to stabilize profits. A stabilization criterion based on the distribution of the internal rate of return is suggested which could be the basis for establishing appropriate transfer rules.

DE HULLU, A. "A Management Oriented Approach to Solvency". Transactions of the Institutional Congress of Actuaries (1984).

This paper aims to provide an overview of the various elements to be considered in an analysis of the solvency position of a specific insurance company and to describe a systematic approach in terms oriented toward management. Illustrations are taken from actual company or intercompany experience. Potential deviations from the projected annual solvency contributions are also studied. These may be caused by stochastic fluctuations, by investment or expense risks, as well as by elements of solidarity among policyholders or by options grants.

FERRARI, J.R. "The Relationship of Underwriting, Investment, Leverage, and Exposure to Return on Owners' Equity". Proceedings of the Casualty Actuarial Society, 55 (1968), 295-302.

The paper sets out basic relationships concerning the return on owners' equity. The importance of investment income is stressed. The actuary must be concerned with the broad financial management objectives of the firm and, in particular, with the analysis of the optimum capital structure.

HARVEY, R.M. "Problems of International Comparability – The Emergence of General Insurance Surplus Under Different Accounting Conventions". Transactions of the International Congress of Actuaries (1988)

This paper identifies the main differences in accounting approaches used in the major European insurance markets and in the U.S.; it illustrates the pattern of profitability and the development of net assets in the period 1971-1985 and reviews recent, current and possible prospective changes in accounting for general insurance. The author believes that there is a clear and important role for the actuarial profession, not just in monitoring, but also in influencing developments in this area alongside the accounting profession.

HUMPHRYS, R. "Standards and Solvency Requirements Under Canadian Insurance Legislation". Transactions of the International Congress of Actuaries (1984)

This paper discusses concepts of solvency and solvency standards under federal insurance legislation in Canada. Defects in the traditional balance sheet presentation are noted and suggestions made for improvement. In this light, Canadian capital and surplus margins are described. Special emphasis is placed on revised methods of reflecting both realized and unrealized capital gains in income statements. The importance of cash flow forecasting is stressed. Reference is made to recent reinsurance problems and the possible effect on balance sheet and other requirements.

KIMBALL, S. and DENENBERG, H. (eds) "Capital and Surplus Requirements". Chapter 6 in Insurance, Government, and Social Policy, Richard D. Irwin Inc., 1969.

The chapter introduces the notion of required capital and surplus and the complementary notion of surplus surplus. The authors argue for ongoing minimum surplus requirements, particularly in respect of insurers owned by holding companies and whose surplus might be transferred to the holding company. The chapter includes a contribution by A.E. Hofflander of UCLA which attempts to provide a framework for a minimum capital and surplus requirement for non-life insurers.

KNEUER, P.J. "Allocation of Surplus for a Multi-Line Insurer". Financial Analysis of Insurance Companies Discussion Paper Program, Casualty Actuarial Society, 1987, 191-228.

Practical difficulties presented by traditional methods for the allocation of surplus to various lines of business are discussed. None of the traditional allocation methods is found to be appropriate. The author goes on to discuss the functions of surplus and practical considerations for making meaningful allocations. It is suggested that performance and profitability measurements be based on insurance operating profit margin rather than on allocations of surplus.

MEYERS, G. "An Analysis of the Capital Structure of an Insurance Company". Proceedings of the Casualty Actuarial Society, 76 (1989), 147-170.

A model of an insurance company is introduced. This model incorporates a collective risk model to describe incurred losses. Account is taken of the underwriting cycle and investors' requirements for a reasonable return on equity. Emerging surplus, which is governed by investors' requirements, is compared to surplus required according to ruin theory and to requirements imposed by regulators.

ROHOLTE, C. "A Fluctuation Reserve System in Non-Life Insurance". Transactions of the International Congress of Actuaries (1988)

This paper presents a fluctuation reserve system in non-life insurance where special emphasis is placed on rules of transition to/from the fluctuation reserve. For a given class of business it is assumed that an aggregate loss distribution can be established, ie. variations in claims experience (number of claims, size of claims, trends and cycles, etc.) is reflected in the distribution function of the yearly aggregated claims. The fluctuation reserve system is characterized by a number of system parameters (system frequency, upper bound, initial reserve, ruin probabilities, etc.) and by an unbiased transition rule. An example is given to show how the system works.

SUGARS, E.G. "A Risk Theoretic Prescription for Regulated Ratemaking". Journal of Risk and Insurance" 39 (1972) 475-478

The author suggests a method, based on risk theory, for determining a fair rate of return in the non-life insurance business. The paper contains the idea that rates should be loaded only enough to allow the insurer a fair return on that part of policyholder surplus funds required to run a prudent insurance business.

B - VIII

Papers on Life Insurance

BRENDER, A. "Solvency Requirements for Life Insurers in Canada". Transactions of the International Congress of Actuaries (1988)

The author discusses the development of life insurance solvency requirements in Canada. The role of the Valuation Actuary is discussed as well as the establishment of guarantee funds. In addition, methods of financial reporting for life insurance are described as well as the development of provisions for adverse deviations. The paper also describes areas of further research into the expanded responsibility of the Valuation Actuary.

BRENDER, A. "The Evolution of Solvency Standards for Life Insurance Companies in Canada". Institute of Insurance and Pension Research, Report #91-10, University of Waterloo, 1991

This paper describes the emergence of the solvency tests and standards for Canadian life insurance companies. The creation and development of the position of Valuation Actuary is discussed. Also, important changes in financial reporting have been introduced in Canada for insurance companies. All reserves will now be on a GAAP basis, and this would apply to both stock and mutual companies. Another important change was the introduction of a Minimum Continuing Capital and Surplus Requirement (MCCSR). The MCCSR is calculated on a going concern basis, at the end of the insurer's fiscal year. A second testing procedure, Dynamic Solvency Testing (DST), has also been developed. The actuary projects the company's affairs under a variety of possible future experiences and tests whether there is sufficient capital and surplus to run off the business. A projection period of five years is suggested. In the initial stages, DST will be carried out using deterministic, rather than stochastic models. The actuary first projects the company's future using "best guess" assumptions, then investigates other scenarios by changing various combinations of variables in the model. These hypothetical results will be examined by company's management and supervising authorities. The model is sufficiently flexible to allow the introduction of stochastic elements whenever the actuary considers this to be warranted.

CANADIAN INSTITUTE OF ACTUARIES "A Primer on Dynamic Solvency Testing", 1989

This paper describes in detail the two main steps in the DST process, namely the projection of surplus trends, and modeling. The projection component is carried out as follows:

(1) calculate historical patterns of actual free surplus and the corresponding required amounts for the most recent three-year period,

(2) project these calculations forward for five years using best estimates of experience and business plans of the company,

(3) recalculate the five-year projections on a set of 10 prescribed scenarios, each of which focuses on a specific single potentially adverse trend in experience,

(4) recalculate the same five-year projections on additional appropriate combination of adverse trends, so as to provide adequate information to management on the hypothetical, plausible and significant threats to the company's financial well-being.

The first scenario tested has the future experience projected based on the best estimates of each relevant factor. This is known as the base scenario. Subsequent scenarios are defined by making prescribed changes in the following areas: mortality, morbidity, withdrawals, increasing interest rates, decreasing interest rates, level new sales, high new sales, sudden high mortality and morbidity, increased default rates, expense rates.

The modeling component of DST involves the development of algorithms to simulate future events, and the selection of cells, or representative blocks of policies and assets which reflect the company's actual portfolio. One possible modeling technique is the projection of gains (or margins) by source. Another possibility is extrapolation in aggregate, meaning that financial statements are projected by studying recent trends in aggregate data for the product line to be projected. The political and economic environment of business must also be considered in the modeling process. Finally, the model must be sufficiently flexible to reflect the variability of the real world.

CANADIAN LIFE AND HEALTH INSURANCE ASSOCIATION "CLHIA Formula for Minimum Continuing Capital and Surplus Requirements", 1991

This paper gives the formula for determining the MCCSR. Each of the following elements receives a particular weight, the total of which comprises the MCCSR.

A. Life Insurance

    1. Mortality Risk

        (a) Insurance (including accidental death and dismemberment)

        (b) Disability and other Morbidity Risks

        (c) Annuities Involving Life Contingencies

    2. Interest Margin Pricing Risk

        (a) participating and non-participating business

        (b)

all other business

3. Asset Default (C-1) Risk

    (a) Short Term Securities

    (b) Bonds

    (c) Mortgages

    (d) Transportation Equipment Trust Certificates

    (e) Bulk Adjustment for Unamortized Gains and Losses on the Disposition of Debt Securities

    (f) Stocks

    (g) Real Estate

    (h) Oil and Gas Production Properties

    (i) Investment Income Due and Accrued

4. Changes in Interest Rate Environment (C-3) Risk

B. Accident and Sickness Insurance

1. Morbidity Risk

    (a) Disability Income Insurance

    (b) Accidental Death and Dismemberment

    (c) Other Accident and Sickness Benefits

    (d) Credits for Reinsurance and Special Policyholder Arrangements

    (e) Adjustments for Statistical Fluctuation.

2. Financial Risk

C. Miscellaneous Requirements

    (a) Reserve for Cash Value Deficiencies and Amounts of Negative Reserve

    (b) Valuation Reserve for Miscellaneous Assets and Other Investments

    (c) Statutory Currency Reserves

    (d) Reserve for Reinsurance Ceded to Unregistered Reinsurers

    (e) Surplus appropriated for special risks not covered by the formula.

FACULTY OF ACTUARIES WORKING PARTY "The Solvency of Life Assurance Companies". Transactions of the Faculty of Actuaries 39 (1986) 251-340

This report represents four years of study by this group although the authors consider their work to be not yet complete. The report describes the work carried out and conclusions reached thus far. One of their conclusions is that the E.E.C. Life Directive solvency requirements do not appear to be based on sound theoretical analysis applicable to current conditions. They also conclude that, by necessity, a stochastic approach must be adopted to establish the solvency margin. Another factor of primary importance in determining a company's solvency is the propriety of asset-liability matching for the company. Finally, the report concludes that it is unlikely that any simple solvency margin, expressed as a percentage of reserves (even if these are calculated on a statutory minimum basis) will be adequate for all companies regardless of the nature of their assets or liabilities.
(II)

HARDY, M. "Aspects of the Assessment of Life Office Solvency". International Conference on Insurance Solvency III, 1991

The standard deterministic methods that U.K. life offices use to assess their own solvency position are compared with stochastic methods for a few very simple model life offices. The stochastic methods, and the model offices used, follow Pentikainen and Pesonen (1988). The deterministic investigations include some ideas adapted from Brender (1988). It is concluded that some stochastic investigation is necessary, if only to determine the "worst case" parameters of a deterministic test.

LAMM-TENNANT, J. "Asset/Liability Management for the Life Insurer: Situation Analysis and Strategy Formulation". Journal of Risk and Insurance 56 (1989) 501-517

This study examines the current operational status and planning procedures of seven asset/liability management processes appropriate for life insurers and offers recommendations. The author discovers that, although most firms consider asset-liability matching to be an important objective, very little has been done to achieve it. The author suggests several methods of integrating asset-liability management into the investment strategy of the insurance business. The objectives of these various methods range from providing solvency on the one extreme, to maximizing returns on the other.

MARTIN-LOF, A. "A Stochastic Theory of Life Insurance". Scandinavian Actuarial Journal (1986) 65-81

A theory of life insurance is considered in which the interest rate is variable and the random fluctuations in the collective are taken into account. The theory explicitly includes a description of how the benefits are changed depending on these factors. A linear feedback which adapts the benefits to the surplus is necessary in order to stabilize the system in the sense that the variance of the surplus remains bounded. Martingale decomposition is a useful tool for the analysis of the fluctuations.

B - IX

Papers on Investment Models

BEEKMAN, J.A. "A Stochastic Investment Model". Transactions of the Society of Actuaries 32(1980) 9-24.

The purpose of this paper is to provide a method for calculating special contingency reserves for investment losses. The method is derived by first building a stochastic investment model and then utilizing its probabilistic structure. The model is essentially the collective risk model used in various ways with respect to insurance claims (both life and non-life). Several examples are examined in considerable detail.

BORCH, K. "The Optimal Portfolio of Assets in an Insurance Company". Transactions of the International Congress of Actuaries (1968).

The author considers the different investment opportunities available to an insurance company. It is assumed that the investments which give the highest return are the least liquid. If the company should be forced to sell such assets in order to pay claims, it will suffer a loss. The author determines the optimal portfolio of assets under different variations of this assumption.

BOYLE, P.P. "Immunization Under Stochastic Models of the Term Structure". Journal of the Institute of Actuaries 105 (1978) 177-187

The author gives a survey of some new results concerning the term structure of interest rates and discusses actuarial applications. The term structure model used in this case assumes zero arbitrage profits. Thus, it represents an equilibrium situation. An immunization strategy is then developed under this assumption. The model does not consider net liability outflow as a random variable, effectively ignoring mortality and other contingencies. In the case of a company with a large portfolio of contracts this procedure can be justified by an appeal to the law of large numbers.

CLARKSON, R.S. "The Measurement of Investment Risk". Transactions of the Faculty of Actuaries 41 (1990) 677-750

The author develops an axiomatic, general theory of investment risk, and demonstrates it with a practical example. The model is then compared to the Markowitz approach. This paper also states that Modern Portfolio Theory is a too narrow interpretation of Markowitz and hence has limited validity. The author also concludes that using the variance of return to measure investment risk is essentially irrelevant in practice, and more effort should be made using advanced analytic techniques to improve the expected return. This paper also makes reference to the work of Wilkie and Wise.

COOPER, R.W. "Investment Return and Property-Liability Insurance Ratemaking". Huebner Foundation Studies, University of Pennsylvania, 1974

This book examines the issue of how to include investment return in the ratemaking process. Four topics are considered: whether to focus on the total resources of the insurer or on the resources required to run the business; necessary level of capital; total rate of return on invested capital; relationship between total rate of return on invested capital, investment return and property-liability insurance rate levels. The author concluded that the focus of regulation should be on the resources required to support a company's insurance business. With regard to the second topic, a formula was derived to determine the necessary level of invested capital, and using this method, the author contends that the ratios of premium to capital and surplus imposed by state regulatory authorities may be too restrictive. To answer the third question, the author used capital market equilibrium theory to derive a "competitive" total rate of return. A model was then derived which addresses the relationship between return on necessary capital, expected investment return and profit provision for a given line of insurance.

COUTTS, S.M., CLARK, G.J. "A Stochastic Approach to the Allocation of Assets for Insurance Companies". International Conference on Insurance Solvency III, 1991.

The authors consider the background to the development of asset and liability modeling and provide an outline of the construction of a particular model. The practical applications of the model are demonstrated, in the first instance by an example of its application in relation to the formulation of investment policy for a U.K. final salary pension scheme. A parallel development appropriate to a general insurance company is then considered, concentrating upon the problem of allocating assets between different asset classes available. The paper concludes with a brief consideration of both the advantages and difficulties of adopting a cash flow approach. A cash flow approach is also proposed as a measure of relative solvency between "peer group" insurance companies.

CUMMINS, J.D., NYE, D.J. "Portfolio Optimization Models for Property-Liability Insurance Companies: An Analysis and Some Extensions". Management Science 27 (1981) 414-430

This paper presents a model to assist property-liability insurance companies in making product and investment mix decisions. A quadratic programming approach is used to generate mean-variance efficient frontiers that reflect the covariability of returns on insurance lines and assets. The solution indicates the overall premium-surplus ratio, the distribution of premiums among insurance lines, and the proportion of assets in each major investment class that are consistent with the minimum level of risk for a given rate of return on net worth. A method is also suggested for including taxes in the model. This paper also discusses the links between ruin theory and utility theory and shows how these decision rules can be used to select operating points along the efficient frontier. A numerical example is given based on the published financial data of a major insurance company.

GEOGHEGAN, T.J. et al. "Report on the Wilkie Stochastic Investment Model". Presented to the Institute of Actuaries, Jan. 27, 1992; to be published in the Journal of the Institute of Actuaries

A FIMAG Working Party was set up in 1989 to consider the stochastic investment model proposed by A.D. Wilkie, which had been used by a number of actuaries for various purposes but had not itself been discussed at the Institute. This is the Report of that Working Party. The Wilkie model is described and reviewed and alternative types of models are discussed. Possible applications of the model are considered, and the important question of "actuarial judgement" is introduced. Finally, the Report looks at possible future developments. In appendices, Clarkson describes a specific alternative model for inflation, and Wilkie describes some experiments with ARCH models. In further appendices possible applications of stochastic investment models to pension funds, to life assurance and to investment management are discussed.

HAUGEN, R.A. "Insurer Risk Under Alternative Investment and Financing Strategies". Journal of Risk and Insurance 38 (1971) 71-80

This article is concerned with the problem of optimizing the structure of assets and liabilities of stock insurance companies. Specifically, an attempt is made to derive some empirical estimates of the risk of return to common stockholders under the assumption that capital is obtained by underwriting insurance from a given line and invested in a securities portfolio of a given nature. By observing and relating the historical performance of insurance and investment portfolios, the variability of the rate of return to equity capital is simulated though the techniques of portfolio analysis.

KAHANE, Y. "Generation of Investable Funds and the Portfolio Behaviour of Non-Life Insurers". Journal of Risk and Insurance 45 (1978) 65-77

In this paper, new parameters, representing the funds generated by the insurance transaction, are introduced into the portfolio model which balances the investment and underwriting activities of an insurer. An insurance activity with a higher funds-generating coefficient may affect both the insurer's expected profit and its risk level. These effects may operate in opposite directions, and the net result would be that a line with a higher coefficient will be less desirable under certain circumstances. Such a surprising impact of the coefficient could have occurred in practice, but the recent experience of insurers, where large underwriting losses are reported, makes this effect less likely today.

KROUSE, C.G. "Portfolio Balancing Corporate Assets and Liabilities with Special Application to Insurance Management". Journal of Financial and Quantitative Analysis 5 (1970) 77-105

This paper considers the simultaneous selection of investments, underwriting lines, and capital financing to form efficient mean-variance corporate portfolios. The analysis is directed toward development of decision rules for use in structuring the firm's business in terms of its balance sheet. The intent is to specify optimal target levels for balance sheet accounts consistent with broad corporate goals, especially in view of the various interrelationships among these "separate" accounts and, consequently, without the suboptimization inherent when considering the properties of each in isolation. The model for unifying these principal, and traditionally disparate, insurance management activities involves only an extension of conventional mean-variance portfolio techniques to include proper specification of:

    (1)   conservation equations balancing the firm's sources and uses of funds,

    (2)   constraints setting legal, market, and institutional restrictions on these sources and uses.

LAMM-TENNANT, J. "Asset/Liability Management for the Life Insurer: Situation Analysis and Strategy Formulation". Journal of Risk and Insurance 56 (1989) 501-517

This study examines the current operational status and planning procedures of seven asset/liability management processes appropriate for life insurers and offers recommendations. The author discovers that, although most firms consider asset-liability matching to be an important objective, very little has been done to achieve it. The author suggests several methods of integrating asset-liability management into the investment strategy of the insurance business. The objectives of these various methods range from providing solvency on the one extreme, to maximizing returns on the other.

PEREZ, E. PRIETO "Determination of the Amounts Available for Long-Term Investment for an Insurance Company". The Geneva Papers on Risk and Insurance No. 11 (January, 1979) 47-51

The author describes two stochastic models (one with, and the other without, reinsurance) to determine the amount that an insurance company can invest for the long term. The models show that the optimal investment decision depends on:

    (i)   the return on the portfolio of assets.

    (ii)   the cost of forced liquidation of assets in order to pay claims.

    (iii) the shape of the claim distribution function $F(x)$.

PEREZ, E. PRIETO "Administration of the Portfolio of an Insurance Company". Transactions of the International Congress of Actuaries (1984)

The author refers to the fact that the demand for a minimum solvency margin from insurance companies permits the partial liberalization of financial resources and implies dropping other methods howsoever aimed at securing the solvency of the insurance company. He recommends the Markowitz method of portfolio selection.

PLATT, ROBERT, B. editor, "Controlling Interest Rate Risk", John Wiley & Sons, New York, 1986

TAPIERO, C.S., ZUCKERMAN, D. "Optimal Investment Policy of an Insurance Firm". Insurance Mathematics and Economics 2 (1983) 103-112

The authors consider an investment problem by an insurance firm. As in the classical model of collective risk, it is assumed that the premium payments are received deterministically from policyholders at a constant rate, while the claim process is determined by a compound Poisson process. They introduce a conversion mechanism of funds from cash into investments and vice versa. Contrary to the conventional model, they do not assume a ruin barrier. Instead they introduce conversion costs to account for the problems implicit in reaching the zero boundary. The objective of the firm is to maximize its net profit by selecting an appropriate investment strategy. A diffusion approximation is suggested in order to obtain tractable results for a general claim size distribution.

TILLEY, J.A. "The Matching of Assets and Liabilities". Transactions of the Society of Actuaries 32 (1980) 263-304

A general model for matching assets and liabilities is developed. Three aspects of the investment problem are discussed: initial investment strategy, reinvestment strategy, and asset liquidation strategy. Reinvestments and disinvestments are handled by an investment-year method. Explicit provision is made for different new-money rates in each future year. The model is defined by specifying:

(1) the schedule of interest and principal payments for representative investment instruments comprising the initial portfolio,

(2) the expected net cash outflows of the pension fund or other block of business,

(3) rollover rates for reinvestments,

(4) a set of patterns of future new-money interest rates.

The model solves for a region of strategies that result in a nonnegative total fund value at the end of the investment horizon for each interest rate pattern in the set described in item 4.

TRIESCHMANN, J.S., MONROE, R.J. "Investment Performance of P-L Insurers' Common Stock Portfolio". Journal of Risk and Insurance 39 (1972) 545-554

This study compares stock P-L, mutual P-L and investment companies with respect to the rate of return on their common stock portfolios. It was found that investment companies earned signficantly higher rates of return, but average risk levels were also higher for these companies. Therefore, investment companies did not earn significantly higher risk-adjusted rates of return than P-L companies. Within the P-L industry, stock companies earned signficantly higher risk-adjusted returns than mutual companies. It was also found that portfolio size and profitability had a low correlation, and that the performance ranking was independent of method of measuring profitability.

VANDEBROEK, M., DHAENE, J. "Optimal Premium Control in a Non-Life Insurance Business". Scandinavian Actuarial Journal (1990) 3-13

Optimal premium control in non-life insurance business is determined using dynamic programming techniques. The optimality is measured in terms of solvency and a sufficient smoothing of the problem and the surplus variations in time.

WILKIE, A.D. "Portfolio Selection in the Presence of Fixed Liabilities". Journal of the Institute of Actuaries 112 (1985) 229-277

This paper was inspired by a paper "The Matching of Assets to Liabilities", JIA (1984), by A.J. Wise. The author discusses assets that are not marketable and cannot be disposed of, so in this sense they are fixed. However, their monetary value is a random variable. This paper is concerned not so much with finding the quantities of assets that match the given liabilities, but rather, finding the most desirable set of assets having regard also to their present prices. The author has generalized conventional portfolio theory by including the price of the portfolio as a third dimension, in addition to the expectation and variance of the ultimate surplus.

WILKIE, A.D. "A Stochastic Investment Model for Actuarial Use". Transactions of the Faculty of Actuaries 39 (1986) 341-403

The author proposes a model to simulate "possible futures". The model is appropriate for long-term studies without being too concerned with short-term fluctuations. This method can be used for valuation of insurance companies, and has been used in many solvency studies. The model treats inflation stochastically, and has four variables to describe the investments for actuarial purposes: retail price index, share yield, share dividend, government securities yield.

WISE, A.J. "The Matching of Assets to Liabilities". Journal of the Institute of Actuaries 111 (1984) 445-501

The purpose of this paper is to present the results of a new study in which the matching position is well defined by reference to appropriate actuarial models. The new theory leads to specific portfolio structures which comprise fixed interest and equity or index-linked investments and which, in a defined sense are the best match to the given liabilities. As will be shown, the advantages of this approach emerge in a variety of applications. In particular it is found possible to quantify aspects of actuarial valuation which would otherwise only be considered in the light of general reasoning. The author restricts his attention to matching portfolios which contain no negative asset holdings.

WISE, A.J. "Matching and Portfolio Selection: Parts I, II". Journal of the Institute of Actuaries 114 (1987) 113-133, 551-568

This paper shows how any efficient portfolio can be divided into three mutually exclusive and distinct components:

(1)   the matching portfolio, which is defined by the property that the expected ultimate surplus is zero and the variance of the ultimate surplus is minimized,

(2)   a component which is related to the expected return on the portfolio but not to its degree of risk,

(3)   a component which is related to the degree of risk in the portfolio but not to its expected return.

The paper is concerned with investment portfolios which involve the liabilities of a long-term investing situation such as a pension fund or a life office. The author addresses the issue that actuarial valuations based on pure matching did not take into account the likely advantage of favouring riskier but potentially more profitable investments. The methods of this paper allow the actuary to choose preferred values for return and risk in the portfolio relative to the liabilities. The author then investigates the problem of finding optimum portfolios with prescribed values of return and risk, but with no negative asset holdings.

B - X

Papers on Ratemaking

BECKMAN, R.W., TREMELLING, R.N. "The Relationship Between Net Premium Written and Policyholders' Surplus". Proceedings of the Casualty Actuarial Society 59 (1972) 203-220.

The authors make the following arguments based on the stock insurance industry premium-surplus ratio for the period 1928-1970:

(1) the stock market is the major factor affecting policyholders' surplus and the premium-surplus ratio.

(2) the premium-surplus ratio measures the leverage of an insurance company and so the stockholders should prefer a higher ratio, but from the policyholders' viewpoint, this ratio is an indication of the strength of the insurer and thus a lower ratio indicates a more heavily capitalized and "stronger" insurer.

(3) the net premium written – policyholders' surplus ratio is distorted because policyholders' surplus has been overstated.

COOPER, R.W. "Investment Return and Property-Liability Insurance Ratemaking". Huebner Foundation Studies, University of Pennsylvania, 1974

This book examines the issue of how to include investment return in the ratemaking process. Four topics are considered: whether to focus on the total resources of the insurer or on the resources required to run the business; necessary level of capital; total rate of return on invested capital; relationship between total rate of return on invested capital, investment return and property-liability insurance rate levels. The author concluded that the focus of regulation should be on the resources required to support a company's insurance business. With regard to the second topic, a formula was derived to determine the necessary level of invested capital, and using this method, the author contends that the ratios of premium to capital and surplus imposed by state regulatory authorities may be too restrictive. To answer the third question, the author used capital market equilibrium theory to derive a "competitive" total rate of return. A model was then derived which addresses the relationship between return on necessary capital, expected investment return and profit provision for a given line of insurance.

CUMMINS, J.D. "Multi-Period Discounted Cash Flow Ratemaking Models in Property-Liability Insurance". Journal of Risk and Insurance 57 (1990) 79-109

Discounted cash flow (DCF) models have become increasingly important in property-liability insurance pricing. This article analyzes the two most common DCF models – the Myers-Cohn (MC) model and the National Council on Compensation Insurance (NCCI) model. The MC model is shown to imply constant capital structure based on present value concepts, while the NCCI model implies constant capital structure based on book values of reserves and surplus. The models reflect alternative and potentially testable hypotheses regarding the timing of equity flows involved in the insurance transaction. Because the equity timing differs, the models do not generally give the same result.

D'ARCY, S.P., GARVEN, J.R. "Property-Liability Insurance Pricing Models: An Empirical Evaluation". Journal of Risk and Insurance 57 (1990) 391-430

In this article, the major property-liability insurance pricing models are evaluated for the period 1926-1985, and the results of the various models are compared in terms of the ability to predict actual underwriting profit margins. Differences between model predictions and realized underwriting profit margin series are examined over the entire period as well as various sub-periods in order to demonstrate how individual models perform under different conditions.

DERRIG, R.A. "Solvency Levels and Risk Loadings Appropriate for Fully Guaranteed Property-Liability Insurance Contracts: A Financial View". International Conference on Insurance Solvency I, 1986.

A model is proposed which applies financial theory concepts, specifically options pricing to the question of required solvency margins. A financial criterion for required solvency margins was proposed as a replacement for the usual statistical ruin criterion. Briefly, a company with an asset/liability ratio of x is solvent at a level $\varepsilon > 0$ if the premium necessary to reinsure its outstanding liabilities is less than ε.

DERRIG, R.A. "The Use of Investment Income in Massachusetts Private Passenger Automobile and Workers' Compensation Ratemaking". Fair Rate of Return in Property-Liability Insurance (ed. Cummins, Harrington) 1987, Kluwer-Nijhoff, Boston

This paper reviews the development of the methodology used to establish underwriting profit provisions for two insurance lines under rate regulation during 1975-1983. Summaries are given of the rates of each of the two lines. A survey of the key parameters and important issues concerning rate measurement is presented. The paper also illustrates the sensitivity of underwriting provisions to the parameters chosen, and compares the actual results for the two lines to the target results established by the various rate approvals.

DOHERTY, N.A., GARVEN, J.R. "Price Regulation in Property Liability Insurance: A Contingent Claims Approach". Journal of Finance 41 (1986) 1031-1050.

A discrete-time option-pricing model is used to derive the "fair" rate of return for the property-liability insurance firm. The rationale for the use of this model is that the financial claims of shareholders, policyholders, and tax authorities can be modelled as European options written on the income generated by the insurers asset portfolio. This portfolio consists mostly of traded financial assets and is therefore relatively easy to value. By setting the value of the shareholders' option equal to the initial surplus, an implicit solution for the fair insurance price may be derived. Unlike previous insurance regulatory models, this approach addresses the ruin probability of the insurer as well as a nonlinear tax effect.

DOHERTY, N.A., KANG, H.B. "Interest Rates and Insurance Price Cycles". Journal of Banking and Finance 12 (1988) 199-214.

Property-liability insurance prices and profit appear to move in a six year cycle. Many industry analysts claim that the insurance market is inherently unstable and prices fail to converge on clearing levels. The authors have a different explanation. They identify spot equilibrium prices using CAPM. But informational, regulatory, and contractual lags preclude instantaneous adjustment. So they model the temporal movement of prices using a partial adjustment model in which actors form rational expectations. The actual movement of insurance prices does seem to track closely those estimated by the partial adjustment model. The cycle may be better viewed as a series of converging responses to changing spot prices.

DOHERTY, N.A., GARVEN, J.R. "Capacity and the Cyclicality of the Insurance Markets". International Conference on Insurance Solvency III, 1991.

Although financial pricing models imply that profits and property-liability insurance firms should conform to an unpredictable time series process, cycles are widely reported. Some controversy exists as to whether the "underwriting cycle" is a mere accounting artifact or whether it has real resource effects. This paper shows that changes in interest rates simultaneously affect the insurer's capital structure and the equilibrium level of underwriting profit. Depending on factors such as asset and liability durations, access to capital markets, and availability of capital substances such as reinsurance, insurers will be differently affected by changing interest rates. Over time, it is found that the average market response to changing interest rates roughly tracks market clearing prices although the response is somewhat damped. However, firms with mismatched assets and liabilities as well as those with more costly access to new capital and reinsurance, are more likely to respond to interest rate changes by either rationing or abnormal price changes.

HAUGEN, R.A., KRONCKE, C.O. "Rate Regulation and the Cost of Capital in the Insurance Industry". Journal of Financial and Quantitative Analysis 6 (1971) 1283-1305

The authors discuss some of the effects of rate regulation in the property and casualty insurance industry. One consequence of the regulatory environment is that an optimal capital structure may clearly exist in this industry. If the rate of return to the insureds is generally deficient, it is expected that property and casualty stock companies would have an incentive to lever themselves to the maximum extent permissible by selling insurance. The classic monopoly of the economic literature finances its lucrative investment opportunities in a competitive capital market. The stock insurance company invests in that market, but the relative distribution of the return earned there may be less than equitable due to the process and standards of rate regulation.

KRAUS, A., ROSS, S.A. "The Determination of Fair Profits for the Property-Liability Insurance Firm". Journal of Finance 37 (1982) 1015-1028

Single period and dynamic valuation models in continuous time, under certainty and uncertainty, are developed for a property-liability insurance contract to determine the "fair" (competitive) premium and underwriting profit. The intertemporal stochastic model assumes that the claim frequency and the price index of claim settlements are functions of a set of underlying state variables which follow a multivariate Wiener process. The competitive premium is shown to be proportional to the claim frequency and the price index for claim settlements at the time the policy is issued. The factor of proportionality varies directly with the claim settlement rate and the length of coverage, and inversely with the risk-adjusted real interest rate on the dollar-valued claim rate.

LAUNIE, J.J., PHILLIPS, G.M. "The Effect of Solvency Regulation in the Underwriting Cycle". International Conference on Insurance Solvency II (1988)

This paper focuses on the frequently utilized regulatory test for capacity which states that net premiums written should not be greater than three times policyholders' surplus. The difficulty with this solvency measure is that net premiums written is immediately affected by price changes. A simple example of the manner in which flows on this measure may exacerbate the underwriting cycle is given. This is followed by a formal model which measures the extent to which changes in net premium written reflects price changes rather than real changes in insurance exposure.

MARTIN-LOF, A. "Premium Control in an Insurance System; An Approach using Linear Control Theory". Scandinavian Actuarial Journal (1983) 1-27

A mathematical model of cash flows and reserves is discussed and a linear control law with feedback for the premium is discussed. The behaviour of the system is analyzed using the methods of control theory. It is shown that stability is maintained only if the feedback is not too strong, and that undesirable oscillations can easily be produced caused by delays in the system. It is shown how a quantitative measure of necessary solidity can be naturally introduced, and consideration is given to the problem of determining the control so that a desired solidity is obtained.

ROSS, J.A., POUNTAIN, C.C. "Comparison of International General Insurance Underwriting Results and their Volatility". Transactions of the International Congress of Actuaries (1988)

This paper studies underwriting results in seven major international markets over the period 1975-1984. The reason for the study is that many companies try to mitigate the underwriting cycle by international diversification. The study shows that Japan, followed by Germany, was the most profitable market, with France being the least. Germany and France had the least variable markets while Australia, followed by the U.S.A., was the most variable. All markets were positively correlated, with Germany being the least so. The conclusion is that since international markets tend to move in the same direction, diversification can limit the worst effects of the cycle but not overcome it.

TAYLOR, G.C. "Solvency Margin Funding for General Insurance Companies". Journal of the Institute of Actuaries 111 (1984) 173-179

The author disagrees with the idea that growth of an insurance company should be financed by premium loadings entirely. He believes that the solvency margin should be viewed as part of the working capital needed to run the company. This will make it necessary to ensure that each year's business produces a return on this margin commensurate with the risks undertaken in the business. However, premiums may still need to contain some loading to provide appropriate return on shareholders' funds. In a sense, then, all growth is to be financed by premium loadings, but only in the form of return on equity, not in the form of what amounts to permanent subscription of capital by policyholders.

TAYLOR, G.C. "An Analysis of Underwriting Cycles in Relation to Insurance Pricing and Solvency". International Conference on Insurance Solvency II, 1988

It is the conventional wisdom of the insurance industry that the total operating profit exhibits cyclical behaviour over time. This paper tries to determine the mechanisms responsible for causing this cycle. It also examines the effects of the cycle in terms of insurer pricing and solvency, and discusses whether regulatory policies might eliminate or mitigate these cycles.

TRIESCHMANN, J.S. "Property-Liability Profits: A Comparative Study". Journal of Risk and Insurance 38 (1971) 437-453

The author studied the risk-adjusted rate of return of the property-liability insurance industry and compared it with non-insurance industries. He concluded that the insurance industry had a statistically significantly lower rate of return than the non-insurance industries that were tested, for the years 1955-1968. He also discovered that "small" insurance firms had significantly lower rates of return than "medium" and "large" insurance firms, but the latter two were not significantly different from each other.

VENEZIAN, E.C. "Ratemaking Methods and Profit Cycles in Property and Liability Insurance". Journal of Risk and Insurance 52 (1985) 477-500

Insurers and rating bureaus often use regression of past costs, or of loss ratios, on time as a way of estimating future rate requirements. A model of this process suggests that the rates set by such methods would create a quasi-cyclical pattern of underwriting profit margins. The details of the forecasting method determine the characteristics of the cyclical pattern, so different lines may have different periods or different phases. Empirical data on major lines of property and liability insurance are consistent with the hypothesis that ratemaking methods contribute to the fluctuations of underwriting profit margins.

B - XI

Miscellaneous Papers

BENJAMIN, S. "Solvency and Profitability in Insurance". Transactions of the International Congress of Actuaries (1980).

This paper gives reasons why the actuarial profession should beware of discussing the financial position of an insurance company (a) within the conceptual framework of GAAP as used for life insurance companies in the U.S.A., and (b) within the conceptual framework of conventional accounting throughout the world for non-life companies. The paper argues that the conventional split between (i) technical provisions (reserves) and (ii) the free assets forming the solvency margin is false. Hence the practice whereby (i) is estimated without regard to the arbitrary level of (ii) which is set by the control authorities, should be unacceptable to the actuarial profession.

The paper argues that the traditional actuarial approach to cautious reserves in life insurance without arbitrary external solvency margins gives an acceptable conceptual framework for both life and non-life insurance accounts, and is consistent with good supervision in a free competitive market. A simple method of assessing the strength of an insurance company, based on past loss-ratios is suggested in an Appendix.

CANADIAN LIFE AND HEALTH INSURANCE ASSOCIATION "CLHIA Formula for Minimum Continuing Capital and Surplus Requirements", 1991

This paper gives the formula for determining the MCCSR. Each of the following elements receives a particular weight, the total of which comprises the MCCSR.

A. Life Insurance
  1. Mortality Risk
    (a) Insurance (including accidental death and dismemberment)
    (b) Disability and other Morbidity Risks
    (c) Annuities Involving Life Contingencies
  2. Interest Margin Pricing Risk
    (a) participating and non-participating business
    (b) all other business
  3. Asset Default (C-1) Risk
    (a) Short Term Securities
    (b) Bonds
    (c) Mortgages
    (d) Transportation Equipment Trust Certificates
    (e) Bulk Adjustment for Unamortized Gains and Losses on the Disposition of Debt Securities
    (f) Stocks
    (g) Real Estate
    (h)

Oil and Gas Production Properties

    (i)   Investment Income Due and Accrued

4.   Changes in Interest Rate Environment (C-3) Risk

B.   Accident and Sickness Insurance

    1.   Morbidity Risk

        (a)   Disability Income Insurance

        (b)   Accidental Death and Dismemberment

        (c)   Other Accident and Sickness Benefits

        (d)   Credits for Reinsurance and Special Policyholder Arrangements

        (e)   Adjustments for Statistical Fluctuation.

    2.   Financial Risk

C.   Miscellaneous Requirements

        (a)   Reserve for Cash Value Deficiencies and Amounts of Negative Reserve

        (b)   Valuation Reserve for Miscellaneous Assets and Other Investments

        (c)   Statutory Currency Reserves

        (d)   Reserve for Reinsurance Ceded to Unregistered Reinsurers

        (e)   Surplus appropriated for special risks not covered by the formula.

(THE) COUNCIL OF THE EUROPEAN COMMUNITIES "First Council Directive for Direct Life Assurance", 1979

This paper gives a determination of the risk-based solvency margin for life insurance companies in the EEC. The solvency margin shall consist of:

(1) assets, including paid-up share capital or paid-up mutual fund; half of unpaid-up share capital or fund once 25% of such capital or fund are paid up; statutory reserves and free reserves not corresponding to underwriting liabilities; any carry-forward of profits.

(2) profit reserves appearing in the balance sheet where they may be used to cover any losses which may arise and where they have not been made available for distribution to policyholders.

(3) (i) an amount equal to 50% of the undertaking's future profits,

   (ii) the difference between a non-Zillmerized mathematical reserve and a mathematical reserve Zillmerized at a rate equal to the loading for acquisition costs included in the premium,

   (iii) any hidden reserves resulting from underestimation of assets or overestimation of liabilities other than mathematical reserves.

Based on these rules, a minimum solvency margin is then determined for the various classes of insurance. One third of the minimum solvency margin shall constitute the guarantee fund, and at least 50% of this fund shall consist of items (1) and (2) above. In addition to this document, a similar one has been drawn up for general insurance.

CUMMINS, J.D., OUTREVILLE, J.F. "An International Analysis of Underwriting Cycles in Property-Liability Insurance". Journal of Risk and Insurance 54 (1987) 246-262

Most prior analyses of underwriting cycles have explained cycles as a supply-side phenomenon involving irrational behaviour on the part of insurers. This paper proposes instead that insurance prices are set according to rational expectations. Although rational expectations per se would be inconsistent with an underwriting cycle, the authors hypothesize that cycles are "created" in an otherwise rational market through the intervention of institutional, regulatory, and accounting factors. Empirical evidence is presented indicating that underwriting profits in several industrialized nations are consistent with this hypothesis.

KASTELIJN, W.M., REMMERSWAAL, J.C.M. "Solvency", Surveys of Actuarial Studies, (May, 1986) No. 3 Nationale-Nederlanden N.V., Rotterdam

This book gives a survey of methods that can be used to calculate solvency margins. The book discusses methods based on ratios, as well as methods based on claims fluctuations or ruin theory. The book also covers the two most comprehensive models in existence: The Finnish Solvency Study, and the GISG Reports on Solvency. The authors also discuss the economic aspects of solvency.

McGUINNESS, J.S. "An Economic Perspective for Controlling Fluctuations in Insurers' Business Results". Transactions of the International Congress of Actuaries (1988).

This paper explores the possibility of establishing criteria for a complete model for studying or controlling the strength of individual insurers. An economic perspective is first suggested for business operations and for their management. Insurance and other security-related activities are next fitted into the managerial pattern. The vital need for a comprehensive approach to managing in a coordinated fashion both random risk and non-random risk is then discussed. Practical implications and applications are finally considered and some conclusions drawn.

NIELSON, N.L., GRACE, E.V. "Capacity as an Indicator of Insurer Solvency". International Conference on Insurance Solvency II, 1988

This paper indicates that, when capacity is defined without consideration of reinsurance, a large proportion of the variance in capacity utilization can be explained by the size of the company, its perceived financial strength, its product mix and capitalization requirements, its organizational form, and the risk of its investment operation. When capacity is defined to include reinsurance the variance in capacity utilization can be more fully explained with half the number of variables. In this formulation a company's perceived financial strength, capitalization requirements, and investment risk offer signficant explanation of capacity underutilization.

OUTREVILLE, J.F. "The Transactions Demand for Cash Balances by Property-Liability Insurance Companies". Journal of Risk and Insurance 54 (1987) 557-568

The critical nature of the demand for cash balances by firms has generated a considerable amount of theoretical and empirical research, although much controversy remains. The study developed in this paper provides empirical evidence in the insurance sector that is consistent with the literature on the existence of economies of scale in the demand for cash balances and the influence of interest rates.

101

PARDO-VIVERO, A. "Reinsurance, Reserves, and Solvency". Transactions of the International Congress of Actuaries (1984)

It is shown that the rules of thumb used by supervisory authorities are not adequate to guarantee solvency in all cases, and in conditions of stagflation it is not rational to tie up money in solvency funds. Reinsurance arrangements are available which can support solvency without the need for excessive funding. This feature has been overlooked lately, as has the need for a rational and consistent taxation policy.

PENTIKAINEN, T. "Aspects on the Solvency of Insurers". Transactions of the International Congress of Actuaries (1984)

The problems related to solvency are reviewed and some solutions and applications are discussed. The importance of profitability, cycles, and inflation is emphasized, taking into account the possibilities of inaccuracies arising from the evaluating of liabilities, and from the fluctuation of the yield of interest, and asset risk. Further, there exists a wide range of miscellaneous incalculable risks in addition to the normal underwriting risks.

PENTIKAINEN, T. "On the Solvency of Insurers". International Conference on Insurance Solvency I, 1986

The author gives an overall view of the solvency issue as he sees it. The following topics are discussed:

   (1)   public supervision and management control,
   (2)   risk analysis, both theoretical and empirical,
   (3)   public solvency control,
   (4)   accounting and analysis systems for solvency management.

RAMLAU-HANSEN, H. "An Application of Credibility Theory to Solvency Margins: Some Comments on a Paper by G.W. de Wit and W.M. Kastelijn". Astin Bulletin 13 (1982) 37-45

This paper criticizes the work of de Wit and Kastelijn. The author argues that the solvency margin need not be the same for all non-life insurance companies. He also considers the figure calculated by de Wit and Kastelijn to be very high. He further states that loss ratio figures alone should not determine solvency margins, but analysts should consider portfolio mixture, claim occurrence, claim distribution, inflation rate and interest earned on premium income.

RANTALA, J. "Adequate Contingency Reserves in Credit Insurance: Report on a Financial Study". Transactions of the International Congress of Actuaries (1984)

This article comprises a summary of a study made in Finland in 1982 concerning the solvency issue in credit insurance. A model is estimated for bankruptcy intensity and average claim size. This model is then used to evaluate the variance in the solvency ratio of the credit insurer. The solvency ratio and appropriate safety loading level are discussed, as well as the potential effects on a credit insurer's solvency of a major economic depression.

SLEE, D.J. "Solvency and Adequacy of Reserves for a Direct Writer of Worker's Compensation Insurance in Australia". Transactions of the International Congress of Actuaries (1984)

The paper suggests that:

    (a) the current solvency formula in Australia is quite arbitrary and by itself it is of little value,

    (b) the actuary is best positioned to monitor and test rather than provide figures for reserves,

    (c) because different lines require different treatment, authorities must have a degree of flexibility in this control of solvency,

    (d) to achieve control with flexibility, companies must not merely pass a static test, but provide a meaningful forward position with an individual pre-agreed solvency plan,

    (e) income generating such pre-agreed solvency requirement should be tax-free,

    (f) bonds should not necessarily be taken at market value for solvency purposes,

    (e) unless all the above concessions are granted, authorities will become inflexible and inevitably stiffen requirements to the point of shareholders throwing in the towel to State monopoly.

STONE, J.M. "A Theory of Capacity and the Insurance of Catastrophe Risks". Journal of Risk and Insurance 40 (1973) 231-243, 339-355

This paper proposes a formal structure for the study of insurance company capacity problems. The first part develops the theory by applying a maximization (of profit) subject to constraints (on stability and survival) model to the risk selection and underwriting process. It is concluded that the stability constraint is generally the operative one and that capacity may be measured as a probability distance from the constraint boundary. In the second part, this format is employed to explore hypothetical examples in catastrophe underwriting and to draw implications about the future of the capacity problem. Here it is shown that the present capacity shortage in the industry could be substantially alleviated by the increased participation of personal lines insurers in the industrial markets and that the shortage may be intensified by the current trend toward corporate self-insurance.

STURGIS, R.W. "Actuarial Valuation of Property/Casualty Insurance Companies". Proceedings of the Casualty Actuarial Society 68 (1981) 146-159

The author describes a basic method for the actuarial valuation of property/casualty companies, based on the economic value of the company. For this purpose he has adapted a classical life company valuation method to determine the capitalized value of expected future earnings. The business in force is considered to be the run of unearned premiums and the losses, expenses, and investment income on premiums already written. Projected earnings on new business are evaluated separately. An example is given of a company writing only workers' compensation, but it can be extended to any number of lines.

TAYLOR, G.C. "Solvency Margin Funding for General Insurance Companies". Journal of the Institute of Actuaries 111 (1984) 173-179

The author disagrees with the idea that growth of an insurance company should be financed by premium loadings entirely. He believes that the solvency margin should be viewed as part of the working capital needed to run the company. This will make it necessary to ensure that each year's business produces a return on this margin commensurate with the risks undertaken in the business. However, premiums may still need to contain some loading to provide appropriate return on shareholders' funds. In a sense, then, all growth is to be financed by premium loadings, but only in the form of return on equity, not in the form of what amounts to permanent subscription of capital by policyholders.

TAYLOR, G.C., BUCHANAN, R.A. "The Management of Solvency". International Conference on Insurance Solvency I, 1986

The authors discuss the following topics:

1. measurement of solvency,
2. factors affecting solvency,
3. management of solvency.

The authors conclude that the solvency margin depends on the following variables:

1. relative exposures to insolvency due to future claims fluctuation and asset fluctuation respectively, measured by the ratio of risk premium to value of liabilities,
2. estimated value of liabilities,
3. expected future rate of increase and variability of unit asset values,
4. size of portfolio, as broadly indicated by claim frequency,
5. contribution to risk of the different lines of business underwritten.